THE BOOK OF STARS

A. FREDERICK COLLINS

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BEING A SIMPLE EXPLANATION OF THE STARS AND THEIR USES TO BOY LIFE

WRITTEN TO CONFORM TO THE TESTS OF THE BOY SCOUTS

BY

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A. FREDERICK COLLINS

"THE BOOK OF WIRELESS"; "THE BOOK OF MAGIC," ETC.

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TO THE BURNHAMS

WITH PLEASANT MEMORIES OF
MOUNT HAMILTON NIGHTS

A WORD TO YOU

The stars are the friends of everyone who knows them.

If you have never stood out in the open and watched the stars on a clear night, you have missed the most wonderful sight to be seen from this little old mud ball of ours, and my advice to you is not to let another night go by without making friends with the stars.

By the stars I mean everything in the far-off sky that we can see, and this includes the white-hot points of light we call the *fixed stars,* the blazing sun, the bright planets, the pale, cold moon, the fiery comets and the burning meteors.

All of these things in the sky are so easily ours to look at, to enjoy and to use, that we are apt not to take them at their true value, just as many of us do not appreciate to the fullest the green grass, the trees, the birds and all the other good things we have without price.

You may wonder how you can make any use of the stars, but there are dozens of ways by which they will serve your purpose, from finding the north to lighting a fire, and from telling the time to sending a signal, and they are all easy to you when you know how.

All the apparatus you need so that you can know the stars is a pair of good, sharp eyes, and if you are fitted with these you are ready to begin your work in starcraft this very night.

A great many folks believe that they must have a telescope with which to see the stars, and while, of course, a great deal more can be seen with a telescope than without one, still it must be remembered that the telescope was invented not longer than four hundred years ago and that many important discoveries in as-

tronomy were made long before the telescope was invented. And, by the way, it was a boy who invented the telescope.

A small telescope, or a pair of field or opera-glasses, will show you many things in the sky which you cannot see with the naked eye, and if you have one of these instruments, by all means use it. On the other hand, you can get along very well without a glass of any kind until you have learned the things that are set down in this book.

To win a *merit badge* in the organization of Boy Scouts, a boy must pass certain tests; but it is just as necessary for you to know the stars as it is for a Boy Scout, and this book is so written that anyone who studies it can pass the Boy Scout tests, and there are a few other things in it which everyone should know.

Once that you have an insight into starcraft, you will never need to be told again how very interesting and useful the stars are, and once that you have mastered the chief points in this book, you should make or buy a telescope having a two- or three-inch objective and get a little closer to the stars.

If any questions should come up which you don't understand, if you will write to me, I will write to you.

A. Frederick Collins.

"The Antlers," Congers, N. Y.

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THE BOOK OF THE STARS

CHAPTER I

HOW TO FIND THE NORTH STAR

If you want to know something about the stars which will be helpful as well as entertaining, the first thing you should do is to be able to find the *North Star.*

The North Star is taken as a starting point in the sky for two very good reasons: first, of all the thousands of stars which the eye can see, it alone never moves; and second, it is due *north* from any place on the Earth's surface from which it can be seen.

It must be plain then that this star is the most important one of all to us, for by its friendly light we can easily tell the points of the compass, though we may be lost in an unknown land or shipwrecked on a strange sea. That is, of course, we can easily find the points of the compass if we have first learned how to find the North Star.

How to Make a Star Finder.—To find the North Star for the first time is a very easy matter if the simple directions given below for making and using a star chart, or star finder, are followed.

Get a smooth pine board, about 16 inches wide, 20 inches long and 7/8 inch thick; make two cleats of wood, each of which is 1 inch wide, 12 inches long and 1/2 inch thick, and screw these to the board near the ends and on the same side, to prevent the board from warping, as shown in Fig. 1. If a drawing board of any size is at hand, it will serve the purpose just as well as a home-made board.

The next thing to do is to obtain a sheet of cardboard about

12 by 16 inches and cover one side of it with a dull black paint; when the paint is thoroughly dry lay it, black side up, on the smooth side of the board.

From another sheet of white cardboard cut out seven stars,

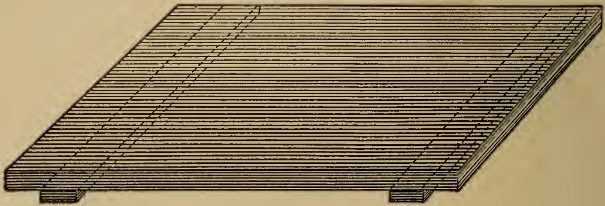


Fig. 1.—Starboard Showing Cleats.

about the size and shape shown in Fig. 2, and cut out another star nearly twice as large, to represent the North Star.

Now place the white stars on the black surface of the cardboard in the positions shown in Fig. 3, using the smaller stars to form the outline of the *Big Dipper* and the large star for the North Star.

Fig. 2. — Cardboard Star.

When all of the stars have been properly arranged, fasten them to the black cardboard with a bit of glue or mucilage. Push a thumb tack, or a pin, through the center of the large star, which is the North Star, and well into the board, so that the chart, or star map, can be turned round on the board with the North Star as its *axis*. When this is done your star finder is complete.

Finding the North Star.—All being in readiness, take this chart, or star finder, out of doors some evening when the *seeing* is good and all the stars in the northern sky are shining brightly, and face about north, holding the starboard in front of you, as shown in Fig. 4.

Usually the direction of north is well known, and yet there are some places where the streets and roads do not run due north and south, and for this reason it is sometimes hard to tell exactly which way is north. In such a place either use a compass to get your bearing, or, if you haven't a compass, face about as nearly north as you know how.

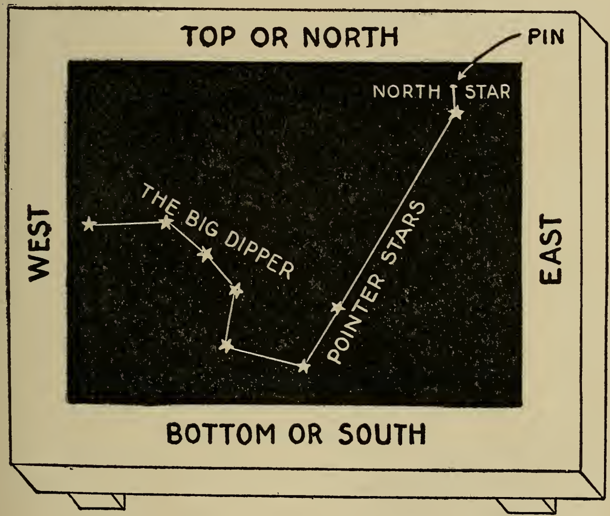


FIG. 3.—THE NORTH STAR AND BIG DIPPER ON STARBOARD.
(Position of Big Dipper in Autumn.)

Having looked at your star chart carefully raise your eyes from the board until they are in a line with the northern *horizon,* that is, the line where the earth and the sky seem to meet. Keep on raising your eyes in a straight line until they reach a group of stars, which is about 40 degrees above the horizon. (See Fig. 98.) The line for sighting the North Star is shown in Fig. 5.

All the stars of this group are very faint except one and this particular star will stand out bright, distinct and alone, for the

other two stars of the same group which can be plainly seen are not very close to it. The star you have found is the *North Star,* or *Pole Star,* or to give it its proper name *Polaris* (pronounced Po-la′-ris).

FIG. 4.—FINDING THE NORTH STAR AND THE BIG DIPPER.

To make sure you have not mistaken some other star for the North Star it will be a good idea to prove your find. To do this turn your eyes to the left a little and you will see a group of seven bright stars fixed in the sky just as the cardboard stars are fixed on the black surface of your chart, and which are shown in Figs. 4 and 5.

The Big Dipper.—This group of seven stars is called the Big Dipper because if a broken line joined all the stars together

a very good figure of a big dipper would be formed. A group of stars is called a *constellation,* and this constellation is shown as we see it in Fig. 6, and as the ancient shepherds and sailors pictured it in Fig. 7.

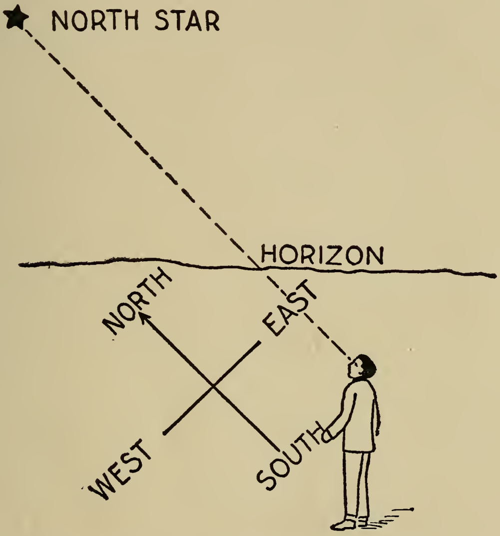


FIG. 5.—LINE FOR SIGHTING THE NORTH STAR.

In England this group of stars, or constellation, is sometimes called the *Plough,* for our friends across the pond see in it the likeness of a plough as well as of a dipper. It is also called the *Great Bear* the world over after the ancient name given it, but it requires some stretch of the imagination to liken it to that nubbly short-tailed animal.

All these fancy names were given this great group of stars long before the birth of Christ and by these names the constellation is still familiarly called. Astronomers of the present time

also call this constellation the Great Bear, but they say it in Latin and so it becomes *Ursa Major,* which is a very high toned and scholastic sounding word. But the Big Dipper is a name that is good enough for all ordinary purposes and so we'll use it.

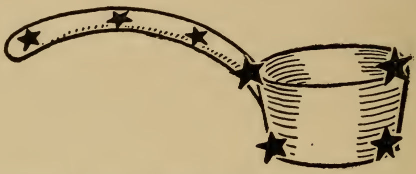


Fig. 6.—The Big Dipper As We See It.

The stars forming the Big Dipper stand out so bright and clear in the northern sky that you won't have the slightest trouble in finding it, especially if you have the star finder at hand to help you.

In using the star finder there is one thing you should keep

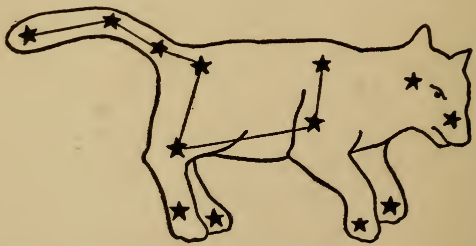


Fig. 7.—The Great Bear as the Ancients Saw It.

well in mind and that is that the Big Dipper as we see it turns round the North Star, like the hands of a clock, but in the opposite direction. That is, the Big Dipper *seems* to turn round the North Star from left to right.

In a word the North Star forms one end of the axis round which not only the Big Dipper but the whole starry heavens

seem to revolve as though they were fastened to the spokes of a great wheel. This is the way it seems to us. As a matter of fact, though, all the stars are *fixed* in their positions in the sky,

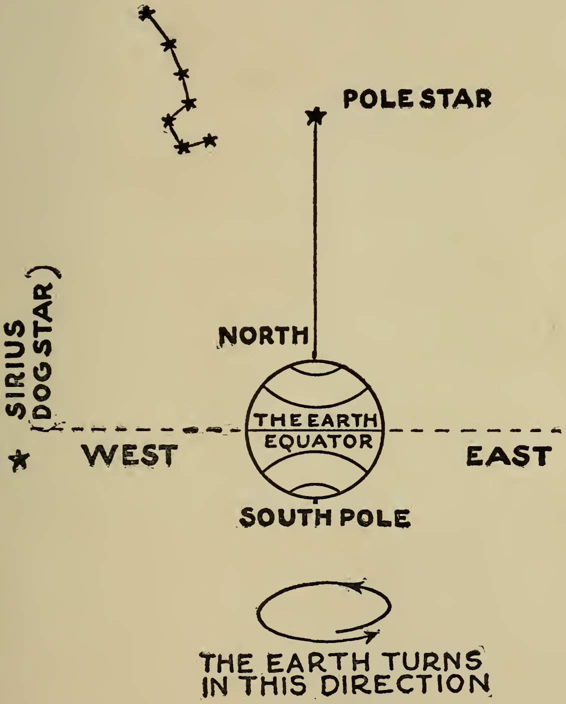


Fig. 8.—The Earth, Pole Star and Dog Star.

and the reason they seem to revolve round the North Star is because the Earth from which we see the stars turns round instead.

By looking at the drawing shown in Fig. 8, it will be seen that the *north pole* of our Earth is directly under the North Star,—hence the name Pole Star—and that if we could draw a line through the center of the Earth from the *south pole* to the *north pole* and extend the line far enough, or *produce* it as it is called, it would finally meet the North Star.

Let us take, now, another star, called the *Dog Star*—its real name is *Sirius* (pronounced Sir′-i-us)—and which is almost on a line with and overhead of the Earth's equator; suppose we are some place on the earth where we can see both the North Star and the Dog Star at the same time, and keeping in mind that the Earth is turning round on its axis; it must be plain, then, that though both of these stars are fixed in the sky and never change their positions we on the Earth will move away from the Dog Star until the Earth has turned half way round, but we will not move away from the North Star.

The eye, however, is easily deceived; for example, if we are on a moving train nearby objects, such as houses, trees, etc., will seem to be moving in the opposite direction to which we are going while we seem to be standing perfectly still. The illusion is much more complete when we are seeing the stars, for the motion of the Earth as it spins on its axis and shoots round the Sun in its orbit is so steady that we cannot notice it; for this reason it seems as if it is the stars which are moving and that we are standing still.

It is easy to understand now why the Big Dipper, and all the other stars, seem to move in great circles round the North Star as well as why the Big Dipper marked with cardboard stars on your chart may not have the same relative position to the North Star as the Big Dipper of real stars in the northern sky, when you view them together as in Fig. 4.

Not only does the revolution of the Earth on its own axis once in every 24 hours cause the Big Dipper to seem to turn round the North Star, but the yearly journey of the Earth round the Sun makes a change in the position of the Big Dipper as we see it at different seasons of the year. And what has been said

about the Big Dipper is just as true of all the other constellations.

For these reasons we would need an almanac to help us keep track of the exact hour when the Big Dipper would be in a given position for every night in the year. But you can always find the Big Dipper any evening in autumn about nine o'clock, by remembering that it is turned right side up as shown in Figs. 3 and 4. Again, if you look for the Big Dipper in winter at

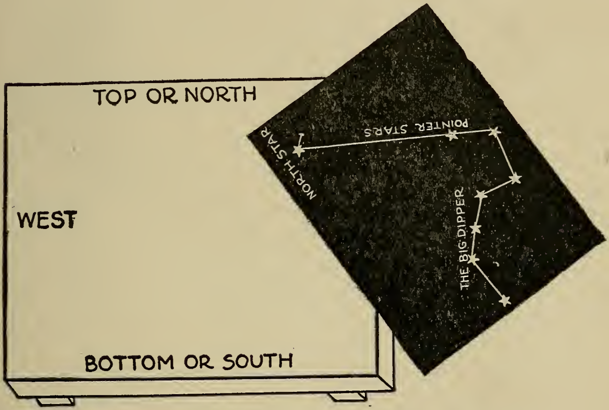


FIG. 9.—THE NORTH STAR AND BIG DIPPER IN WINTER.

about nine o'clock in the evening you will find it standing on its handle a little to the east as in Fig. 9. In spring about 9 o'clock, it will have moved on round the North Star until it is upside down, as in Fig. 10, while in summer, at 9, it is hung up by its handle high in the sky, as shown in Fig. 11. The four positions of the Big Dipper during the same hours of the different seasons are shown in Fig. 12, which also shows the four positions of the Big Dipper during each 24 hours.

By turning the chart round on the board from left to right you will soon come to a point where the Big Dipper of paper

stars and the Big Dipper of real stars are in exactly the same position.

You have, no doubt, noticed that a line joins the two end stars of the Big Dipper and the North Star in Figs. 3, 4, 10, and

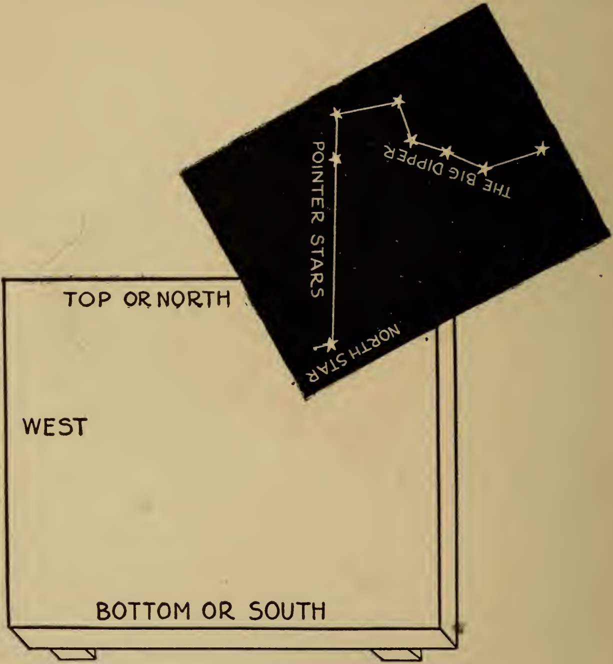


FIG. 10.—THE NORTH STAR AND BIG DIPPER IN SPRING.

11. These two end stars of the Big Dipper are called *pointer stars,* for they point directly to the North Star; that is if we draw a line with the eye through the pointer stars and produce, or continue the line, it will run into the North Star, nearly.

By using these pointer stars it is easy for any one who knows the Big Dipper to be able to find the North Star on any clear night in the year, for the Big Dipper can be seen the year round.

The seven stars which form the Big Dipper are not the brightest stars in the sky by any means, yet each one is a great white sun as large or larger than our own Sun.

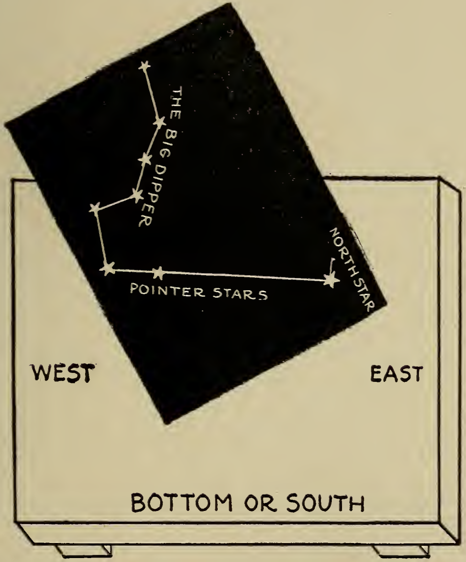


FIG. 11.—THE NORTH STAR AND BIG DIPPER IN SUMMER.

Now look sharply at the middle star in the handle of the Big Dipper, whose name is *Mizar* (pronounced Me′-zar), and see if you can make out another little star whose name is *Alcor* (pronounced Al′-cor) hugging up close to it. The Arabs who named them called these two stars the *Horse* and its *Rider*. If you can see this little star Alcor you will have cause to shake

hands with yourself, for if your eyes are good you can see it and if they are only fair to middling you cannot see it. This is one of the famous Arab tests for eyesight.

How to Tell Time by the Big Dipper.—We have seen how the Big Dipper seems to turn round the North Star and this be-

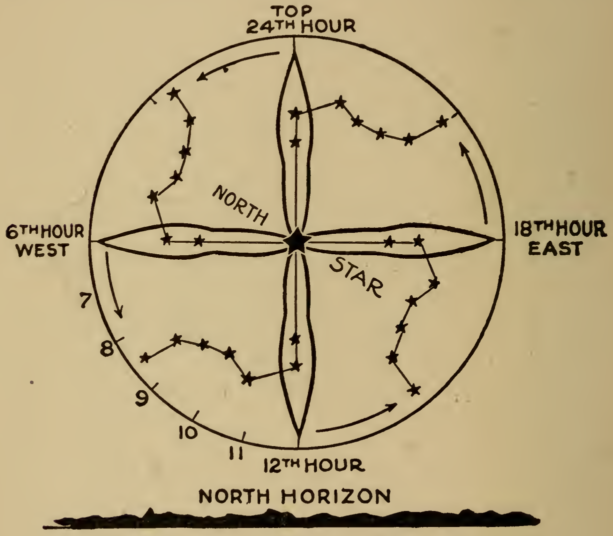


FIG. 12.—TELLING TIME BY THE BIG DIPPER.

ing the case we can use the pointer stars for the hour hand of a big star clock.

You must always bear in mind, though, that while the hands of a clock turn from right to left, the Big Dipper swings round from left to right; and there is another thing to be kept in mind and that is while the hour hand of a clock goes *twice* round in 24 hours, the Big Dipper revolves only once in 24 hours, and for this reason the hand formed by the pointer stars

of the Big Dipper moves only half as fast as the hour hand of a watch or clock.

Each quarter of the circle, then, is equal to 6 hours and by dividing the quarter circles into 6 equal parts you can mark off the hours. The best way to do this at first is to make a large drawing of Fig. 12 on your starboard and compare it with the Big Dipper; then draw an imaginary circle round the North Star in the sky so that it will just clear the last star in the handle of the Big Dipper. With some practice you will be able to tell the time within half an hour or less.

In telling the time by the Big Dipper you must remember that the stars in turning round the north pole run fast an hour every 15 days, and this makes them gain 6 hours in 3 months and so they gain a complete revolution in a year. But every time the Big Dipper makes one complete turn round the North Star, one complete day, as measured by star time, will have passed.

CHAPTER II

HOW TO KNOW THE STARS

One of the tests a Boy Scout must pass in order to obtain his badge of merit for starcraft is to be able to name and point out twelve principal constellations, and every boy, whether he is a scout or not, should be able to do the same thing for his own good.

The word *constellation* is formed from two Latin words, the first being *con* which means *together,* and the last being *stella* which means *star,* or in plain English, constellation means *stars together.*

In your efforts to find the North Star you have already learned one of the principal constellations—that of the Big Dipper—and to learn more of them will be even easier and much more fun, for now you have learned the game.

The Constellation of Cassiopeia.—To find the constellation of *Cassiopeia* (pronounced Cas′-i-o-pe′-ah) again make use of your star finder. Remove all the stars from the blackened cardboard and rearrange them so that the North Star is in the center of the board and the Big Dipper is on the left-hand side with the two pointer stars in a line with the North Star. On this chart the Big Dipper must be made much smaller than the one described in the first chapter.

Cut out five more stars from white cardboard and place them on the opposite side of the board from the Big Dipper in such a manner that they will form the letter **W** being careful to fasten the stars to the cardboard so that the letter **W** stands in the exact position shown in Fig. 13.

A line drawn through the pointers of the Big Dipper and produced will, as before, pass through the North Star, and if it

is extended an equal distance beyond it, will pass very closely to the constellation of Cassiopeia; this line will aid you in placing the stars on your chart in the right positions.

Having thus prepared the star finder, take it out into the open when night comes on and begin by locating the North Star and the Big Dipper. Now set the Big Dipper and the North Star of your star chart in a position which to your eye corresponds to the Big Dipper and the North Star in the sky. Follow the line from the pointer stars to the North Star and beyond when the great letter **W** which is the constellation of Cassiopeia, will stand out so clear and bright that you will wonder why you have never seen it before.

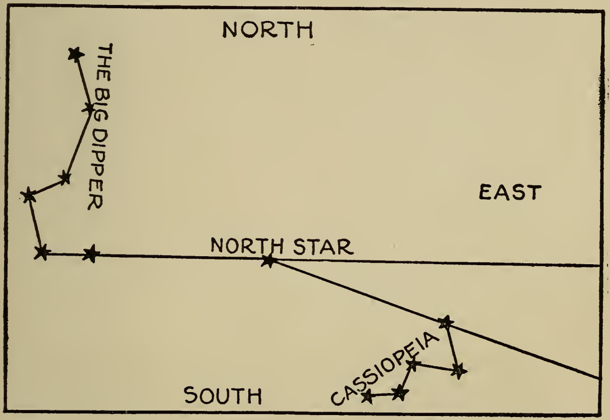


Fig. 13.—Constellation of Cassiopeia.

Fig. 14 shows this group of stars and the outline of the unhappy Cassiopeia who is as often standing on her head as on her feet, but it requires the imagination of an Arabian stargazer to see the likeness.

The Little Dipper.—Although some of the stars which

form the *Little Dipper* are very faint it is included in our list of 12 principal constellations for two reasons: first, because it contains the very important North Star, and second, because it is easy to find.

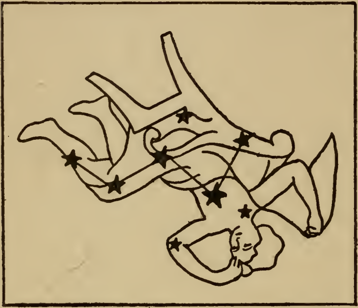


Fig. 14.—Cassiopeia as the Arabs Saw Her.

The North Star is the last star in the handle of the Little Dipper. The two outer stars which form the bowl of the Little Dipper, and which are called the *Guardians of the Pole,* are quite bright, and after a few trials you can easily put in the stars that are too dim to be seen, and so complete in your mind's eye the outline of the Little Dipper as you have it on your chart. Fig. 15 shows the arrangement of the stars in

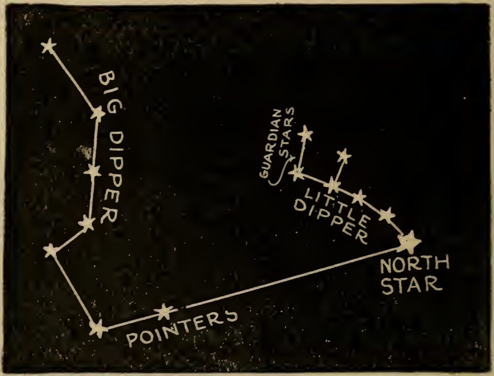


Fig. 15.—The Little Dipper or Little Bear.

the Little Dipper and the relative position of the Little Dipper to the Big Dipper.

The Little Dipper is also called the *Little Bear* and this latter name when done into Latin becomes *Ursa Minor,* which is its scientific name. How the Little Dipper was made into a Little Bear by the ancients is shown in Fig. 16.

The Great Square of Pegasus.—Unlike the Big Dipper, the Little Dipper and Cassiopeia, which are so close to the North Star that they never set and hence can be seen at any hour of the night and at any season of the year, we now come to some constellations which are quite distant from the North Star and are for this reason to be seen only at certain times of the year. The *Great Square of Pegasus* can always be seen on clear, crisp nights during the autumn months.

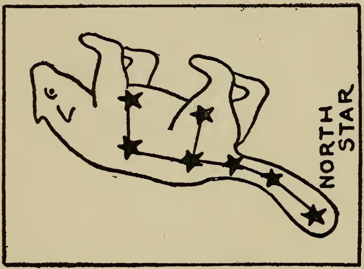


FIG. 16.—THE LITTLE DIPPER MADE INTO A LITTLE BEAR.

To find a constellation that is as far away from the North Star as Pegasus (pronounced Peg′-a-sus) is not an easy thing to do, at least the first time you try it, for while our chart is marked with a straight line the sky is like a great bowl and a line produced from the North Star to Pegasus will, in consequence, not be a straight line, but a curved line. However, with your star finder charted like the diagram shown in Fig. 17 you will be able to locate Pegasus with very little effort.

After taking off all the stars from the cardboard surface, pin or paste the North Star to the lower left hand corner of the black surface of the cardboard and place the five stars of Cassiopeia in their proper positions. Now draw a line from the North Star through Cassiopeia just below the star marked β

which is the Greek letter *beta* (see Appendix C) and produce, or extend that line until the edge of the cardboard is reached. On the extreme right hand end of this line set two stars, which we will also call pointer stars, and place two more stars above them so that a nearly perfect square will be formed as shown in Fig. 17.

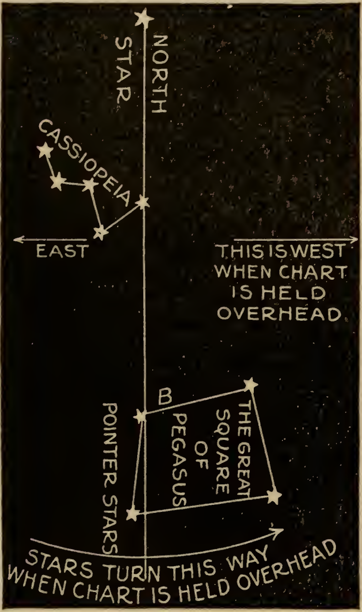


Fig. 17.—The Great Square of Pegasus.

To find Pegasus take the star chart out-of-doors, say some evening in September about 9 o'clock, for the Great Square will then be on the *meridian,* that is, on a line directly over your head and which runs north and south across the sky. This time, instead of looking down on the chart, as you did in finding the Big Dipper and Cassiopeia, turn the board bottom side up, as shown in Fig. 18, but still keeping the cardboard North Star pointing north and the four stars of Pegasus pointing toward the south.

By looking over your chart into the sky and following an imaginary line with your eye from the North Star through Cassiopeia past the star β (beta) and lengthening this line toward the equator in the southern sky you will come upon four bright, white stars which form the Great Square of Pegasus,

and you have added another and fourth constellation to your list.

The practical value of knowing the mighty constellation of Pegasus is that you can always find the north, by means of its friendly stars, though the North Star, the Big and Little Dippers and Cassiopeia are hidden by clouds. To find the north

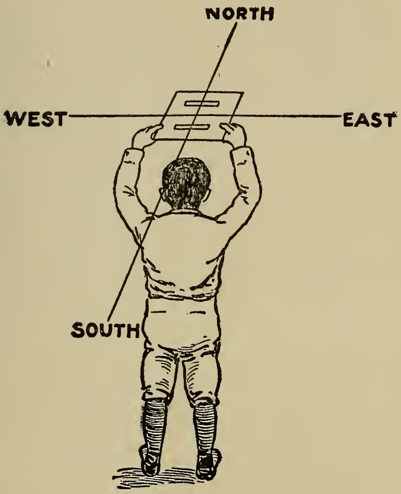


Fig. 18.—Holding the Chart of Pegasus Overhead.

you only have to run an imaginary line through the pointer stars of Pegasus and produce it until it reaches the northern horizon.

The Great Square of Pegasus was fancifully pictured by the ancients as a *Flying Horse* and, curiously enough, with only half a body at that, as shown in Fig. 19. To those who do not know the lore of the stars it is not so easy to see in the Great Square the fabled winged steed who still continues his flight through

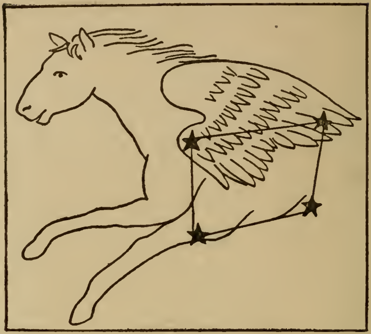


FIG. 19.—THE FLYING HORSE OF PEGASUS.

the sky just as he did when he was invented over four thousand years ago.

FIG. 20.—FIGURE OF A TRAPEZIUM.

The Mighty Orion.—The brightest constellation in the whole sky is *Orion* (pronounced O-ri′-on), the Great Hunter, as the ancients liked to imagine this group of stars.

With the exception of the Big Dipper, Orion is the easiest of all the constellations to find provided you look for it at the right time of the year, which is during the winter months.

To locate Orion cut out of cardboard seven large stars and

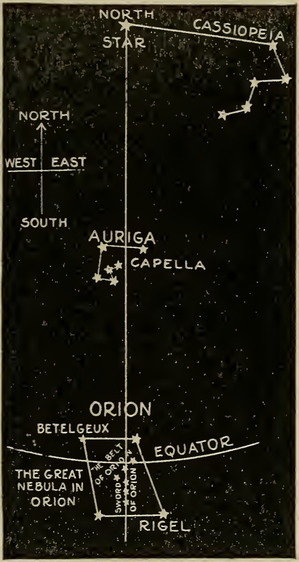


FIG. 21.—CONSTELLATION OF ORION.

three small stars. Near the lower edge of the blackened cardboard pin two large and two small stars to form what is called a *trapezium,* that is, four straight lines forming a figure, none of which are parallel, as shown in Fig. 20. About halfway across the figure pin three large stars in a row, at equal distances apart and tilted a little, as shown in Fig. 21.

These three stars form the *Belt of Orion,* for a mighty hunter must needs have a belt, and this belt of bright stars is

one of the best known groups in the whole sky. Across the belt and nearly at right angles to it pin three small stars; these small stars form the sword or dagger of the fanciful hunter but they are of more use to us than to him, as will be seen presently.

At the top of the star chart pin the North Star so that it will be in a direct line with the three small stars forming the *Sword of Orion.* Your star chart of Orion is now ready to be compared with the one in the sky. The best time to find Orion

Fig. 22.—Orion the Mighty Hunter.

is in November about 9 o'clock, when the constellation is high in the southern sky, though he may be seen shining in all his glory all winter long.

On taking your star chart out-of-doors hold it overhead just as you did in finding the Great Square of Pegasus; now look toward the south until your eyes rest on the equator running across the southern sky from east to west and you will see the mighty Orion, though you may not recognize the lion skin he holds.

Having found Orion draw an imaginary line through the three small stars called his sword and produce this line until it

meets the North Star. Once you have found Orion you will never again require the help of a star chart to locate him, but it is a good plan to look him up as often as you can, and to draw the imaginary line through his sword and on to the North Star, for should you ever lose your way or want to find the

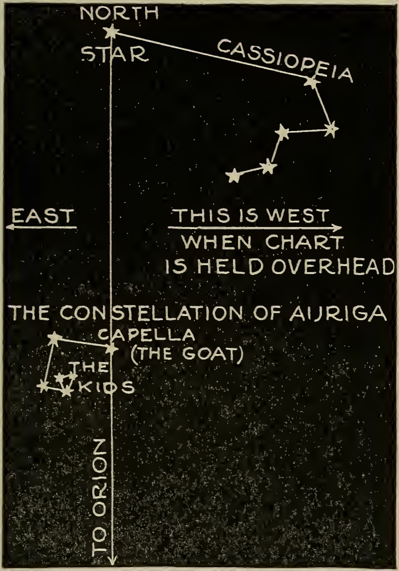


FIG. 23.—CONSTELLATION OF AURIGA.

north and the North Star should be hidden by clouds a line through the Sword of Orion will direct you as certainly as the needle of a compass. Fig. 22 shows the fabulous Orion as a giant hunter holding the skin of a lion which he killed, according to Arabian star lore.

Auriga, the Charioteer or Shepherd.—After finding Orion the constellation of *Auriga* (pronounced Aw-re′-ga) will get

right in your way so that you cannot by any chance miss it. This is because the chief star in Auriga and whose name is *Capella* (pronounced Ca-pel′-la) lies nearly on the line drawn through the Sword of Orion and produced to the North Star as shown in Figs. 21, 23 and 27.

Auriga was pictured by the Assyrians as a charioteer, but the early Greeks saw in this constellation a good shepherd, who carried a goat on his back and two kids in his arms. The bril-

Fig. 24.—Auriga the Shepherd.

liant star Capella is supposed to be the goat and the three small stars which form a triangle close to Capella are the kids as shown in Fig. 24.

When the North Star cannot be seen the star Capella will prove a useful aid with Orion in finding the north; and since it is just about half way between Orion and the North Star it may again be useful in judging the distance of the North Star from Orion when the former star is obscured.

The Constellation of Taurus.—The last constellation which need concern us here is *Taurus* (pronounced To′-rus) the Bull. Taurus is one of the constellations of the *zodiac* of which we

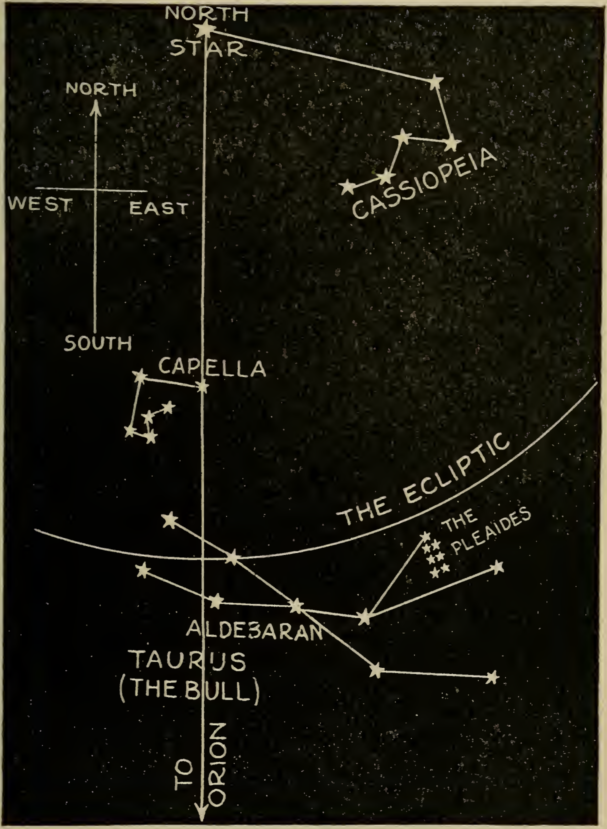


FIG. 25.—CONSTELLATION OF TAURUS.

will have something to say in Chapter XI. By the time you have learned the foregoing constellations you will be able to locate Taurus without using your star chart, for it lies to the north of Orion, to the south of Auriga and a little to the west of both of these constellations as you will see in Figs. 25 and 27.

The little group of stars nearby is the *Pleiades* (pronounced plai′-e-dez), and is a part of the constellation of Taurus.

FIG. 26.—TAURUS THE BULL.

There are six small but bright stars grouped closely together when seen by the ordinary person, but if you have very sharp eyes you may be able to make out one or two more.

It is believed that the stars of Taurus were the first to be woven into a group or constellation by the ancients, and it is thought that the *Bull of Light,* as Taurus was called, was known long before the time of Abraham, or over four thousand years ago. Fig. 26 shows Taurus as the Egyptians saw him. The bright red star which sets in the right eye of Taurus is called *Aldebaran* (pronounced Al-deb′-a-ran) and is the third

brightest star in the sky. In the star chart shown in Fig. 27 the different constellations you have learned are grouped together in the same positions in which they are placed in the sky.

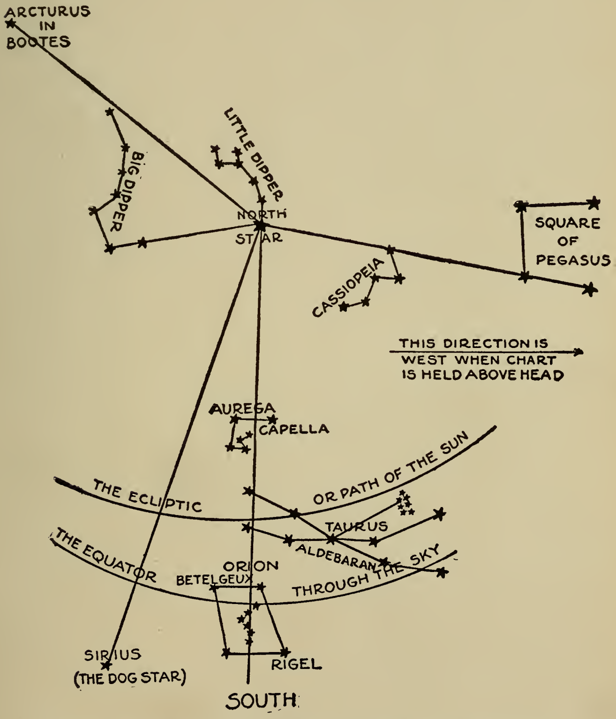


FIG. 27.—STAR MAP SHOWING SIX CHIEF CONSTELLATIONS.

Six stars of the first magnitude, that is 6 of the 20 stars which shine the brightest (see Appendices F and G), are also shown on the chart, Fig. 27. By following the equator from

west to east across the bowl of the sky, and which runs right through the middle of Orion, you will find to the west and south of it the brightest star in the heavens—*Sirius,* the Dog Star, so named because it is in the constellation of *Canis Major,* which is Latin for Big Dog.

Capella in Auriga is the third brightest star, and *Arcturus* (pronounced Arc-tu′-rus) which can be found by following the handle of the Big Dipper, is fourth in brilliancy. The fifth place is held by *Rigel* (pronounced Rai′-gel) in Orion; *Aldebaran* in Taurus is sixth in order, and *Betelgeux* (pronounced Bet-el-gerz′) in Orion comes last.

There are many other constellations and a large number of other stars but when you are able to name and point out those described in this chapter you will have made a very good running start.

CHAPTER III

THE SUN, THE BRIGHTEST OF ALL STARS

In naming over the stars of the first magnitude—that is, the stars that shine the brightest—there is one star I did not mention and yet as we see it it is brighter than all the other stars put together.

This great star is our *Sun* and since we owe everything we possess on Earth to him—light, heat, power and even life itself—he should and does stand in a class by himself, though after all he is just as much of a fixed star as the North Star, the Dog Star, or any of the thousands of other stars which we see as mere points of light in the sky.

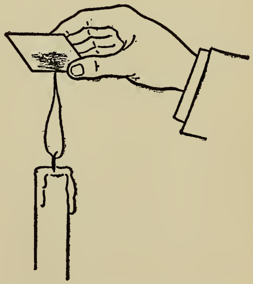


Fig. 28.—Smoking Glasses over Candle Flame.

How to See the Sun.—You must never look directly at the Sun with the naked eye, for he is so powerful that his light will injure your sight for all time.

There are several ways, though, to observe the Sun without danger to your eyes and as all of these are simple and cost nothing you can easily try them. The most common way is to take a bit of window glass, say an inch square, and smoke one side of it over the flame of a candle, as shown in Fig. 28.

When this blackened glass is held closely to the eye, as shown in Fig. 29, and the latter is directed toward the Sun, a little circle of light will appear on the film of smoke and the surface

of the Sun may be examined at length and without the least danger.

A decided improvement over the smoked glass idea is to use a piece of red, or a piece of yellow glass, as an eyepiece, or, better, place the red and yellow glasses together and bind the edges with paper. Another plan to see the Sun without injury to the eyes is to make a hole with the point of a needle in a visiting card and look through the hole directly at the Sun.

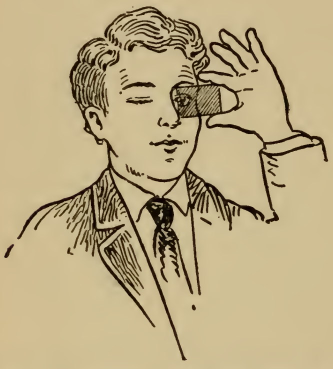


Fig. 29.—Seeing the Sun through Smoked Glasses.

A still better view of the Sun can be obtained if a pinhole telescope is used. A telescope of this kind can be easily made without tools, metals or lenses. It is described and pictured in Chapter IX.

To observe the Sun hold the pinhole end of the tube closely to your eye, to cut off all the outside light, and sight the tube so that the Sun shines directly into your eye through the pinhole, and you will get a very brilliant view of the great yellow star which we call the Sun.

What the Sun is Made of.—When a candle is lit the wax of which it is made begins to melt and this is drawn up the wick where it is changed into gas and the burning gas forms the flame.

The flame of a candle is made up of four parts, which are really layers of heated gas surrounding the wick, as shown in Fig. 30. In the center of the flame is the wick; the first layer of gas is at the bottom of the flame and this gives a greenish-blue light; the second layer is the dark and cool part of the

flame; the third layer is a cone of heated gas which gives out the bright light, and surrounding this cone is a faint blue light which can just be seen.

We know, of course, what the candle is made of and we also know why it burns and in a way how it gives off light and heat because we have examined it closely, but if we could get no nearer a candle flame than a quarter of a mile it is very doubtful if we could ever be able to learn anything about the real source of the flame—that is its greasy wick.

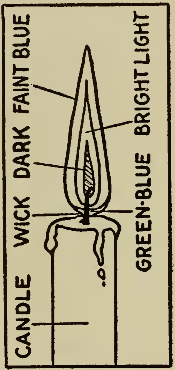


FIG. 30.—A CANDLE FLAME SHOWING LAYERS OF FLAME.

It is much the same with the Sun, for we can only examine it at a great distance and know it by its action on our senses, for the flaming layers of the Sun are so bright that no one ever saw through them, so the real source of its light and heat—the core of the Sun—remains unknown. Fig. 31 shows the Sun as we see him.

Since the Sun gives out light and heat it is easy to believe that it is a great ball of burning gases and from what astronomers have learned of him with their wonderful instruments this idea seems to be pretty well founded.

The Sun must be a tremendously hot body—for the iron and other metals in it are not only melted but they boil away like water and are changed into gases. Under certain conditions gigantic flames, called *prominences,* shown in Fig. 32, can be seen to leap from the edge, or *limb,* as it is called, of the Sun, and finally, great holes, called *sun spots,* are formed on the Sun that are so large a dozen worlds the size of our Earth could be dropped into any one of them and rattled around like marbles in a cigar box. These are a few of the reasons we are led to believe that the Sun is a seething ball of fire.

The Sun's Layers of Flame.—Just as the wick of a candle

is surrounded with several kinds of flame, so the Sun has three layers of flame around a central core.

The core of the Sun is believed to be formed of liquid gases which are about as thick as New Orleans molasses.

Around this core, which is the real source of the Sun's light and heat—and which has never been seen—is a dark layer of flame usually called the *Sun's surface;* this layer, which is cov-

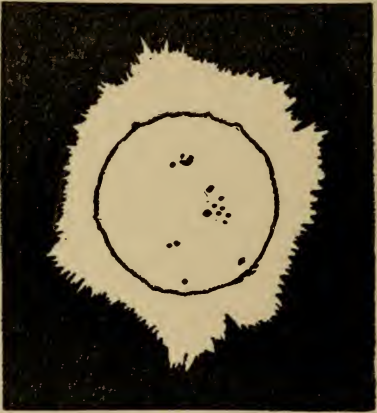


FIG. 31.—THE SUN AS WE SEE IT.

ered with numerous dark spots like freckles on the face of a red-headed boy, is called the *photosphere,* and it is this part of the Sun which gives out the most light.

The second layer, which is called the *chromosphere,* is about 5,000 miles thick, and if you could imagine the whole world afire you would then have but a faint idea of what a mighty seething sea of flame this layer is. It is in this layer of burning gases that terrific explosions take place and red tongues of flame, or *prominences,* are shot out for upwards of 300,000 miles.

Around the chromosphere is another layer of flame which

extends for hundreds of thousands of miles in all directions. This last layer is called the *corona,* and it is as thin as the stuff of which dreams are made. It is formed of burning hydrogen and since it is so thin it can never be seen except when there is a total eclipse, that is when the Moon passes between us and

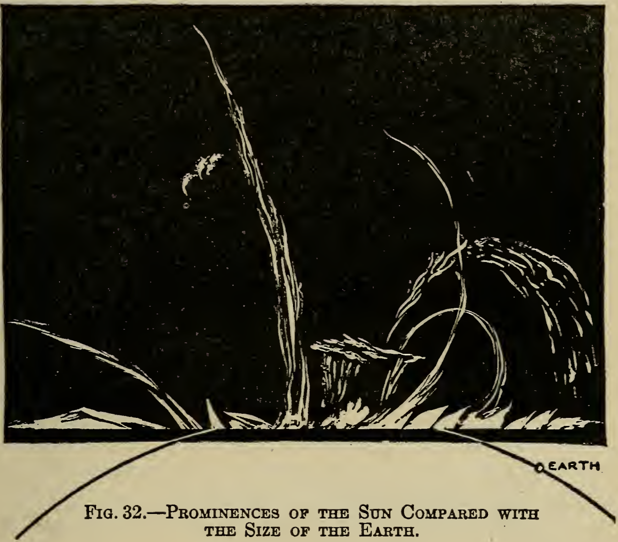


FIG. 32.—PROMINENCES OF THE SUN COMPARED WITH THE SIZE OF THE EARTH.

the Sun, which will be explained in Chapter VII, and so shuts out the intense light of the other two layers. A cross section of the Sun is shown in Fig. 33.

Sun Spots and Their Effect on the Earth.—Very often great spots are seen on the Sun's surface. These purplish black spots appear to be holes, like the craters of volcanoes, in the photosphere, or layer of flame next to the core of the Sun. The sun spots are caused by great eruptions which take place in the core of the Sun, and these sun spots, or holes, are sometimes

over 100,000 miles in diameter, when they can be easily seen with the naked eye; indeed if a sun spot has a diameter only as large as that of our Earth, it can be seen with the naked eye, protected, of course, with either a smoked or a colored glass, or better, with a pinhole telescope; in any case it will look like a

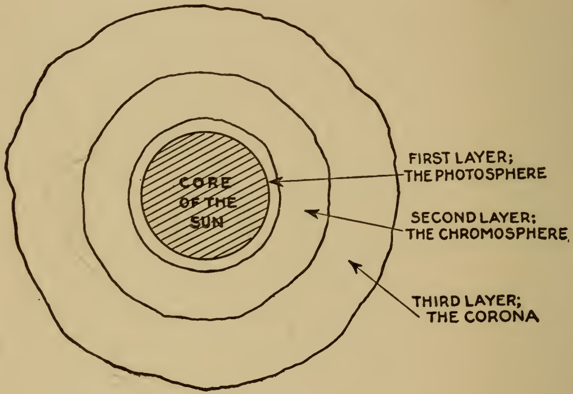


Fig. 33.—Cross Section of the Sun.

black speck about the size of a pinhead. Fig. 34 shows a view of a sun spot made through a large telescope.

Whenever the sun changes his spots *magnetic storms* take place on the Earth, when compass needles, telegraph and telephone apparatus and wireless systems are disturbed. When a large number of spots appear at the same time on the Sun the *Northern Lights* are very bright. Sun spots, however, have nothing to do with our weather, as the heat reaching the Earth is always the same.

The Sun and the Weather.—Of course the Sun has everything to do with the weather, but to be able to predict the kind of weather we shall have even the next day is a very hard thing to do.

The changes in the weather are caused by the heat of the Sun alone. The heat of the Sun produces clouds by vaporizing the water of rivers, lakes and oceans. He causes hot and cold weather by heating some parts of the air more than other parts, and this sets the air in motion and we call this movement of the air the wind.

Changes of heat, moisture and wind are the cause of all the kinds of weather we have, and we have a good many kinds, be it hot or cold, dry or wet, calm or windy, clear or stormy, good, bad and indifferent.

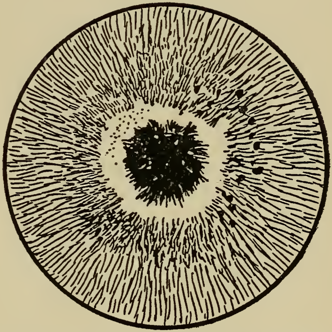


Fig. 34.—Sun Spot in Photosphere

To Forecast the Weather by a Barometer.—The best way to tell what the coming weather will be in the next few hours is by the rise and the fall of the *pressure* of the air, or *barometric pressure*, as it is called.

A simple *barometer* for showing the changes in the pressure of the air can be made of a glass tube about 3 feet long, ½ inch in diameter, and closed at one end as shown in Fig. 35. Fill the tube with mercury and, placing your finger over the mouth of the tube, turn it upside down and put the open end into a cup, or other vessel, which is half full of mercury; in placing it into the cup be careful that no air gets into the tube.

Only a small part of the mercury in the tube will run into the cup and this will leave a space in the top of the tube. Now fasten a yardstick, the purpose of which is to show the changes in the height of the mercury in the tube, with a string or wire to the tube, and your barometer will be complete, as shown in Fig. 36.

Since the air presses on the mercury in the cup but not in the tube, the pressure of the air on the mercury in the cup just balances the weight of the mercury in the tube and, hence, any increase or decrease in the pressure of the air, which ordinarily is about 15 pounds to the square inch, is shown by the rising or the falling of the mercury in the tube.

The weather as *forecasted* by a barometer shows that: (1) when the mercury *rises* in the tube, that is when it is high, the

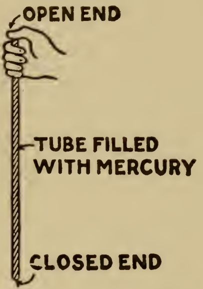


Fig. 35.—Barometer Tube.

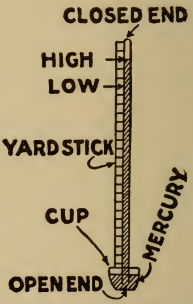


Fig. 36.—Barometer Complete.

weather will be *fair;* (2) when the mercury *falls* in the tube, that is when it is low, *bad* weather may be looked for; (3) when the mercury *suddenly falls* in the tube a *storm* is coming, and (4) when the mercury continues at a *high point* the weather will remain *fair.*

To remember these forecasts easily they may be briefly stated thus:

(1) A *high* barometer shows *fair* weather.

(2) A *low* barometer shows *bad* weather.

(3) A *sudden fall* of the barometer shows a *coming storm.*

(4) A *constant high* barometer shows continued *fair* weather.

To Forecast the Weather by Signs.—It will seldom happen that a boy who goes camping, or one who otherwise wants

to know what the weather is likely to be on the morrow, will have a barometer to consult, so the next best thing is to know how to read the weather signs:

(1) "Red at night is the sailor's delight" is an old forecast, and means that the morrow will be a fine day.

(2) "Red in the morning is the sailor's warning," which means that rain is coming.

(3) A golden sunset is a sign that a high wind is coming.

(4) A yellow sunset is a sign that rain is coming.

(5) When the Sun sets clear it is a sign of a fine day on the morrow.

(6) When the Sun sets behind a cloud it is a sign that the next day will be cloudy or rainy.

(7) A misty dawn shows the coming of a fine day.

(8) A low dawn, that is when the Sun shines clear on rising, shows the coming of a fine day.

(9) A high dawn, that is when the Sun rises over a haze, or clouds, shows wind.

To Light a Fire with the Heat of the Sun.—A small *magnifying glass,* or burning glass, is simply a convex lens. It is a little piece of apparatus that every boy should always carry with him just as he does his pocket knife and compass. A lens 1½ inches in diameter and having a 4-inch focus may be bought for 25 or 30 cents.

A lens of this kind will be found very useful in many ways, for it will greatly magnify any object such as cloth, leaves, insects, finger-prints, in fact anything you may wish to see better than you could with your naked eye, though you cannot use a single lens for a spyglass. A magnifying glass will also frequently come in handy for lighting fires, by using the Sun's rays when matches are scarce.

While a Boy Scout would disdain to use paper to kindle a fire, yet if a scrap of paper is at hand it will prove a good medium on which to direct the rays of the Sun with a burning glass. If you have no paper focus your glass on some *punk* or very dry leaves, as shown in Fig. 37.

To focus the glass means to hold it away from the paper or leaves so that the rays of the Sun are brought to a point like the sharpened end of a lead pencil; when all the rays of sunlight, each of which carries a little heat, are brought to a point, they will make enough heat to light a piece of paper or a dry leaf.

Fig. 37.—Boy Focusing Burning Glass on Leaves to Make Fire.

Signaling with the Sun's Rays.—There are many ways of sending a signal or a message across space by day, as, for instance, by means of smoke, by flags and flashes of sunlight; by bonfires, pine-knot flames and burning arrows by night, and by wireless, which can be used either by day or by night.

A simple and effective way to signal in the daytime when the Sun is shining is by using a mirror, that is, a looking-glass, as it is commonly called. Every boy knows how to make flashes with a mirror, so it will be enough to say here that the glass is held in the hand in such a position that the sunlight falling upon it will be reflected in the direction you wish to send the signals. Fig. 38 shows how it is done.

Any sort of a code can be used, but it is far more interesting

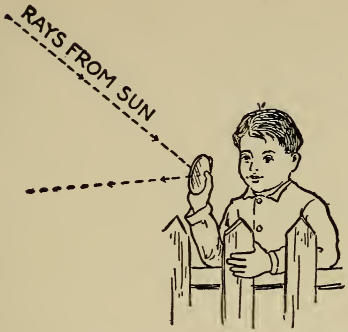


FIG. 38.—BOY SENDING FLASH SIGNAL WITH MIRROR.

and will prove very useful if you are able to send and receive messages in the dot and dash alphabet, or Morse telegraph code, which is given in Fig. 39. A short flash represents a dot, a

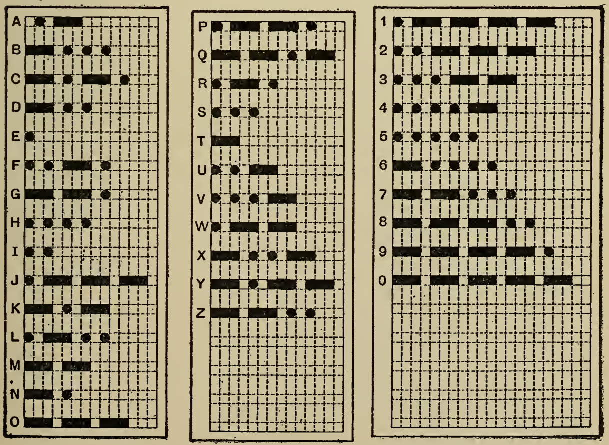


FIG. 39.—CONTINENTAL MORSE CODE.

long flash a dash and short and long flashes represent letters. This is the same code that is used for wireless telegraphy.

How to Make a Simple Heliograph.—A *heliograph* is merely a mirror mounted on a baseboard, but this is a big improvement over holding the mirror in the hand, for to send and receive flashes over long distances the mirror must be carefully aimed and kept in position.

To make a heliograph, get a board 12 inches long, 4 inches wide and 1 inch thick and cut a piece out of one end 4 inches

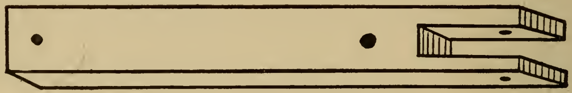


FIG. 40.—BASE FOR HELIOGRAPH.

long and 1 inch wide, as shown in Fig. 40. Bore a ¼-inch hole through the slotted end and another ¼-inch hole 4½ inches from the slotted end, as shown in the cut.

Make a block of wood 4 inches long, 1 inch wide and 1 inch thick and bore a ¼-inch hole through it near one end. To the other end of this stick fasten a mirror about 4 inches square. This mirror should be perfectly smooth—a plate glass mirror is the best—and have a hole $^1/_{16}$ inch in diameter drilled through the center of the mirror for sighting the heliograph, as shown in Fig. 41. Any optician will drill the hole for you for a quarter or less. Fig. 42 shows a top view of the heliograph and Fig. 43 shows a side view of it.

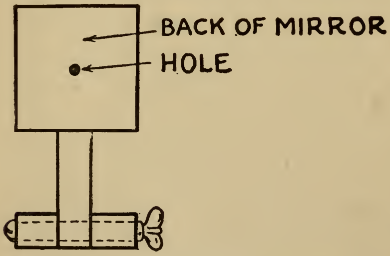


FIG. 41.—BACK VIEW OF HELIOGRAPH.

Make a wood frame so that the mirror can be fastened in it and screw the frame to a stick of wood. Get a bolt 5 inches long and ¼ inch in diameter and have a thumb screw fitted to it. Set the end of the stick which has the mirror fastened

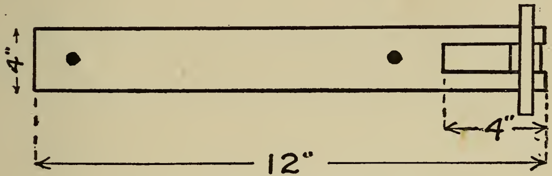


FIG. 42.—TOP VIEW OF HELIOGRAPH.

to it into the slotted end of the baseboard, push the bolt through the holes and after slipping on the washer put on the thumb screw. The mirror can now be moved to and fro.

Into the hole in the front part of the base put a wire or a

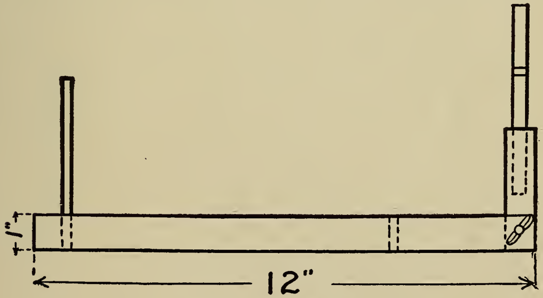


FIG. 43.—SIDE VIEW OF HELIOGRAPH.

thin round stick to sight the mirror by. The heliograph is now ready for use.

After sighting the mirror at the place where the signals are to be received, set the mirror so that the reflected beam of sunlight shines directly on the place. To send signals in the

Morse code all you need to do to make dots and dashes is to place a sheet of cardboard before the mirror and take it away; the length of time the mirror remains uncovered determines whether it is a dot or a dash. The heliograph complete is shown in Fig. 44.

How to Make a Simple Sundial.—To make a sundial of the usual kind that will give the correct Sun time is not an

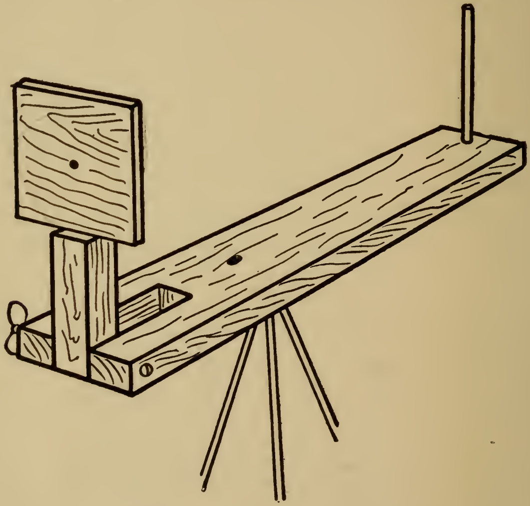


Fig. 44.—Heliograph Complete.

easy matter, for the spaces marking the hours on the dial are not equal as they are on the face of the clock and this will make it hard to figure out.

A kind of sundial that will give the correct Sun time though, can be easily made and at little cost. Get a strip of tin 2 inches wide and 24 inches long; mark it off into 24 equal spaces like those on a two-foot rule, and beginning at one end with the

number 1, number each space to 24, as shown in Fig. 45. This done, bend the strip of tin into a perfect ring with the numbers inside and solder the joint, as shown in Fig. 46.

Next get a strip of iron or brass ¼ inch wide, $^1/_{16}$ inch thick and 13 inches long; drill a $^1/_{16}$ inch hole through each

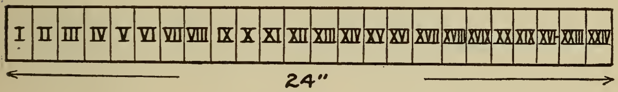


FIG. 45.—NUMBERED STRIP FOR SUNDIAL.

end and a ⅛-inch hole 4 inches from one end; bend this strip into an exact semi-circle, as shown in Fig. 47 and solder the tin ring, at the point where numbers 1 and 24 meet, to the middle of the brass semi-circle. Through the holes in the ends of the brass semi-circle fasten a wire, and this wire must run

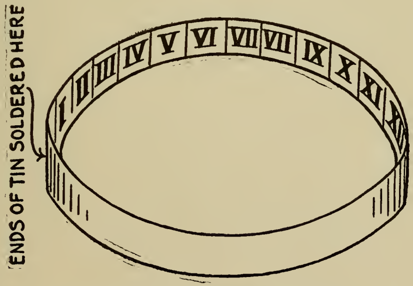


FIG. 46.—TIN RING FOR SUNDIAL.

exactly through the center of the tin ring. Now screw the brass semi-circle to a baseboard (see Fig. 48), so that the angle made by the wire and the surface of the board will be equal to the latitude of the place where it is to be used; in other words, when the board is level the wire should point directly to the North Star and when this is done it will be adjusted to

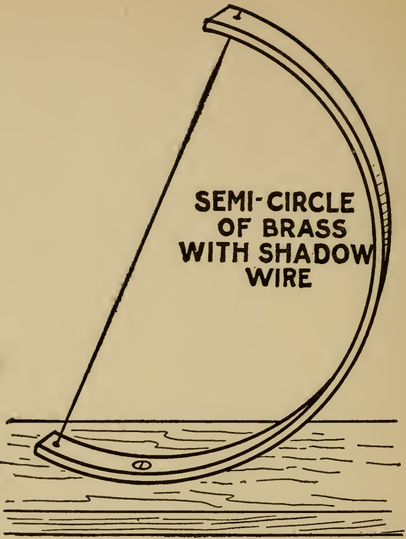


FIG. 47.—BRASS SEMI-CIRCLE WITH SHADOW WIRE.

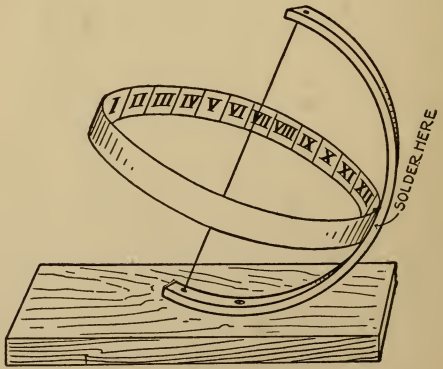


FIG. 48.—SUNDIAL COMPLETE.

the proper angle. The board should be about 12 inches square and 1 inch thick.

Since the shadow of the wire made by the sunlight will fall on XII at noon, it will be plain that the shadow of the wire falling on the numbers on one side or the other of the ring will mark the Sun time. To change Sun time to *mean solar time,* or ordinary time, see *Equation of Time,* Appendix ~~M.~~ L.

To Find the North by a Watch.—To use a watch as a compass, that is to find the north by means of a watch, is easy

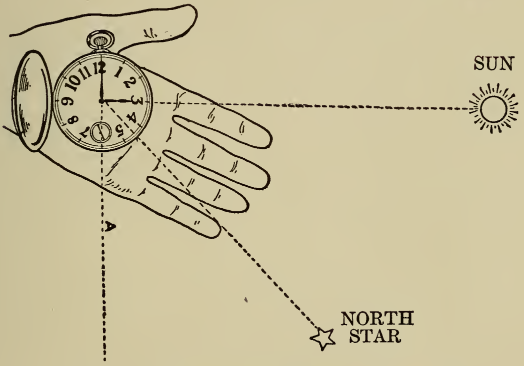


Fig. 49.—To Find the North by a Watch.

if the Sun is shining. The watch should be held face upward; then turn the watch around until the hour hand points in the direction of the Sun. Draw an imaginary line from the hour XII through the center of your watch to the hour VI (that is the center of the second hand) and produce the line, or extend it, as shown by the dotted line.

If, now, in the middle of these two lines which form an angle you draw another line from the center of the watch and produce, or extend it, the middle line will point just about north, all of which is clearly shown in Fig. 49.

CHAPTER IV

THE PLANETS, THE SUN'S KIDDIES

In the last chapter we said that all the stars in the sky, including our Sun, are fixed in their positions; by this we mean that if we were to look at the Big Dipper every night for a hundred years we could see no change in the positions of any of the stars forming this constellation.

But if we look at the sky along the line of the *ecliptic*—that is the path of the Sun—one night after another we are likely to see a bright point of light which looks exactly like a star and yet it is certain that this point of light really does move among the other stars. What kind of a heavenly object then is this?

A bright point of light which thus seems to us to be a star when we look at it with the naked eye is really another world, or *planet* as it is called, and very like our own Earth. To prove that this moving point of light is really a world, or planet, and not a distant star, all you need to do is to look at it through a pair of opera glasses, or a small telescope, when it will be seen to be a round body, whereas a star when viewed through the greatest telescope is never larger than a mere point of light. (See Fig. 50.)

Fig. 50.—A Star and a Planet in a Telescope.

The reason the planets, some of which are smaller and some larger than our Earth, can be seen to move is because they are quite near our Earth; that is, they are near when compared with the fixed stars.

Again, the reason the planets shine like the stars is not

because they are hot and flaming bodies like our Sun and the other stars, but because the light from the Sun which strikes them is reflected to the Earth in exactly the same way that the sunlight falling on a mirror is reflected away in another direction.

Names and Sizes of the Planets.—The names of all the planets, and there are eight chief ones, should be learned as well as the order in which they are arranged around the Sun. The names of the planets are given below in the order of their size.

MERCURY—The smallest planet and the one nearest the Sun. Pale ash in color. Has no moon.

MARS—The Red Planet. Reddish in color. Has two moons.

VENUS—Called the Evening Star. Brilliant straw in color. Has no moon.

EARTH—Our own planet. Has one moon.

URANUS (pronounced Yew′-ra-nus) — Called Herschel's planet. Pale green in color. Has one moon.

NEPTUNE—The planet farthest away from the Sun. Has four moons.

SATURN—The planet with the rings. Its color is a dull yellow. Has ten moons.

JUPITER—The largest planet. He is marked with lines called belts. He has nine moons. Bright silver in color.

THE ASTEROIDS—A group of small planets, the largest of which is about 300 miles in diameter.

How to Know the Planets.—While it is not an easy thing to tell a planet from a star with the naked eye, still there are several ways of doing it.

First, always look for the planets along the path which the Sun and Moon travel. As all the planets are in the same plane with the Sun and Moon they must all follow the same path across the sky.

Second, it is useful to remember that none of the planets, except Mercury, ever twinkle, unless they are very near the horizon.

Third, by watching a planet closely for a few hours it will be found to have moved a little. To note this change of position the planet and some fixed star near it must be closely watched and their distances compared from time to time.

Fourth, and last, the surest way of finding the different planets is by using an almanac which will tell you which planets

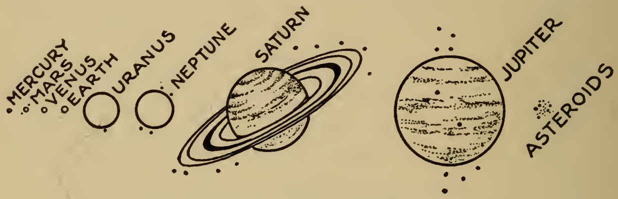


Fig. 51.—Sizes of Planets Compared.

can be seen at certain times of the year and in what part of the sky they are to be found.

Seeing Mercury.—*Mercury* is so near the Sun that it can only be seen with the naked eye at certain times. Mercury should be looked for just above the eastern horizon for about an hour before the Sun rises in the spring; and above the western horizon for about an hour after the Sun sets in the autumn. You will have no trouble in knowing Mercury if you can only see him, for of all the stars in the heavens he twinkles the hardest. His pale ash color will also help you to single him out from the stars about him. Mercury goes through *phases* like our Moon, but these cannot be seen with the naked eye.

Mercury is a curious planet in that his day and his year are of exactly the same length, just like our Moon; this means that he turns on his axis once in exactly the same length of time it takes him to travel round the Sun. This causes one side of Mercury to be always turned toward the Sun, and of course this side is hot and light, while the other side is always turned away

from the Sun and, consequently, it is dark and cold. Three views of Mercury as seen through a telescope are shown in Fig. 52.

Mercury is 36 millions of miles from the Sun.
His diameter is 3,000 miles.
His day is 88 of our days long.
His year is 88 of our days long.

FIG. 52.—THREE VIEWS OF MERCURY.

Seeing Mars.—We hear more of *Mars* than of any other planet for two reasons: first, because great lines can be seen on his surface which are thought to be canals, and second, since Mars sometimes comes closer to the Earth than even Venus, there has been a great deal of talk since the invention of wireless telegraphy about our signaling to him.

FIG. 53.—MARS AS SEEN THROUGH A TELESCOPE.

That people could live on Mars there is no doubt, for the Red Planet is like our Earth, in that it has land, water and air, weather and seasons, with a warm equator and ice-covered poles. Seen through a telescope he looks like Fig. 53, though much smaller.

But Mars cannot always be seen, for sometimes he disappears for a couple of years, but when he finally does return he is a good planet, for he stays a long time, and you cannot mis-

take him, for he will shine ruddy and bright with never a merry twinkle.

Mars is 141 millions of miles from the sun.

His diameter is 4,200 miles.

His day is 24½ of our hours long.

His year is 687 of our days long.

Seeing Venus.—*Venus* is so much brighter than any of the other stars or planets that you will know her the instant you see her. Indeed, when Venus is the brightest and the Sun is

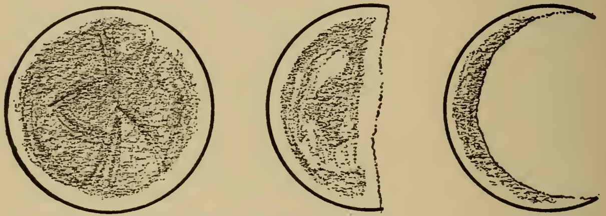


FIG. 54.—THREE VIEWS OF VENUS.

far enough away from her, she can often be seen with the naked eye in the daytime if the sky is clear. Three views of Venus are shown in Fig. 54.

To see Venus you must look for her early in the morning in the east before the Sun is up, or in the evening in the west just after the Sun has gone down. This is the reason Venus is sometimes called an *evening star* and sometimes a *morning star.* Venus goes through phases like Mercury and our Moon, but these cannot be seen with the naked eye.

When Venus and the Sun get too close together she cannot be seen, for the light of the Sun is so powerful that her reflected light is dimmed by it. Venus is a bright straw color and she is a beautiful object in the sky when visible, but there are months at a time when she cannot be seen, either by reason of the Sun's rays outshining her or by being hidden from view on the other side of the Sun. The day and the year of Venus are, like Mer-

cury and our Moon, equal and hence, one side of Venus is always turned toward the Sun and basks in its light and heat, while the other side is turned away from the Sun and is doomed forever to cold and darkness.

Venus is 67 millions of miles from the Sun.

Her diameter is 7,700 miles.

Her day is 225 of our days long.

Her year is 225 of our days long.

Our Earth.—The *Earth* is the third planet in distance from our Sun, and although it is small compared with some of the

Fig. 55.—The Earth.

Fig. 56.—Jupiter.

others it is so important to us that it will be described in a separate chapter. Fig. 55 shows a view of the Earth as she would be seen from the Moon.

The Earth is 93 millions of miles from the Sun.

Her diameter is 7,920 miles.

Her day is 24 hours long.

Her year is 365 days long.

Seeing Jupiter.—*Jupiter,* the largest planet which revolves round our Sun, is fifth in distance from him. He is not as bright as Venus, but he is brighter than any of the fixed stars, and by his brightness and silvery color he is quite easy to recognize.

This great planet seems not to have cooled down yet into a nice world like our own Earth or someone's else Mars, but rather he is a ball surrounded by clouds of hot vapor. Still he

is not hot enough to give out any light himself, but like the rest of the planets he shines by the reflected light of the Sun. Fig. 56 is a view of Jupiter as seen through a telescope; only one of his moons is shown.

Jupiter is crossed with several bands and he has nine moons to light up his great surface on a dark night, but neither his belts nor his moons can be seen without a glass.

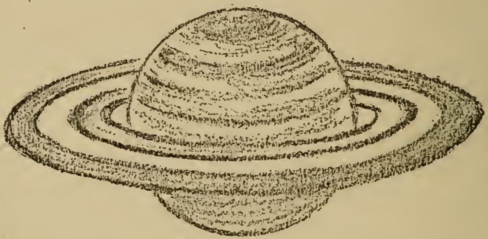


FIG. 57.—SATURN.

Jupiter is 483 millions of miles from the Sun.
His diameter is 87,000 miles.
His day is about 10 of our hours long.
His year is almost 12 of our years long.

Seeing Saturn.—It is not an easy matter to single out *Saturn* with the naked eye, for his light is just about as bright as Capella in the constellation of Auriga, or any of the other first magnitude stars.

This disadvantage is offset by the fact that when he rises at sunset he can be seen during the whole night, so that you will not only have plenty of time in which to find him, but to observe him as well. Again, Saturn may be seen any clear night during the winter months until the year 1920.

Like the Earth, Saturn is believed to have a more or less solid core, but hotter and with layers of gas around him. It is the sixth planet from the Sun, and with his beautiful rings, which are formed of millions of little pieces—each a moon in

itself—and with his ten large moons, when seen through a telescope he is far and away the mightiest sight in the whole sky at night. He and his wonderful rings are shown in Fig. 57.

Saturn is 886 millions of miles from the Sun.

His diameter is 87,000 miles.

His day is 29 of our days long.

His year is 29 of our years long.

Seeing Uranus.—If you have sharp eyes and will look for *Uranus* in the spring and summer months, you should be able

FIG. 58.—URANUS.

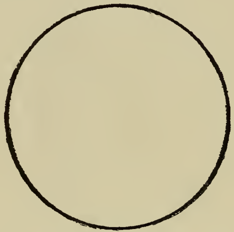


FIG. 59.—NEPTUNE.

to see him. He has a pale green color, and is a star about as bright as the Guardian Stars of the Little Dipper.

Uranus is the seventh star from the Sun and before Herschel discovered him with his homemade telescope astronomers frequently mistook him for a fixed star. A view of Uranus as seen through a large telescope is shown in Fig. 58.

Uranus is 1,780 millions of miles from the Sun.

His diameter is 73,000 miles.

His day is 10 of our hours long.

His year is 86 of our years long.

Neptune.—*Neptune* is so far away from the Sun he cannot be seen with the naked eye, and the largest telescope just shows him to be a planet. He is attended by one moon. He is simply a disk of light when seen through a telescope, as shown in Fig. 59.

Neptune is 2,790 millions of miles from the Sun.

His diameter is 36,000 miles.

His day is unknown.

His year is 165 of our years long.

The Asteroids.—The *Asteroids* are a group of small planets moving around the Sun in an orbit between the Earth and Mars and, hence, at times these little bodies come very close to

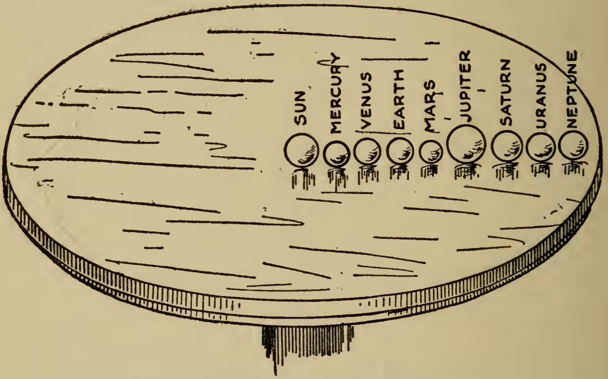


FIG. 60.—MARBLES ON TOP OF TABLE.

us. The group occupies a place in the sky where we should expect to find a single large planet.

But when the planets were made, Jupiter, with his great bulk pulled the soft pieces apart of which a planet would have been formed, and instead of one planet of respectable size there are hundreds of little planets ranging anywhere from 20 miles to 300 miles in diameter.

One of these small planets is called *Vesta,* and although she is only 240 miles in diameter she may be seen on certain occasions with the naked eye.

Positions of the Planets Round the Sun.—It was mentioned in the beginning of this chapter that all of the planets

lay in the same *plane,* and that this plane is in a line with the Sun's equator. Now let us see just what this means.

Suppose we lay eight marbles around a large marble placed on top of a table and in the center. This means that all the

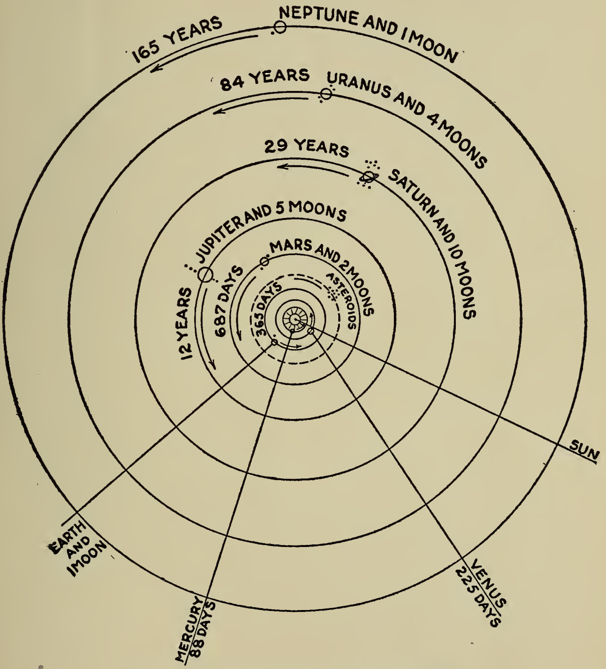


Fig. 61.—Top View of Solar System.

marbles lie in the same plane which is the top of the table, as shown in Fig. 60. The planets are all arranged round the Sun, as shown in Fig. 61, just the same as if they were all placed on a big, level board or table top. If we draw a picture of the plane view of the planets (Fig. 60) and the top view of the planets

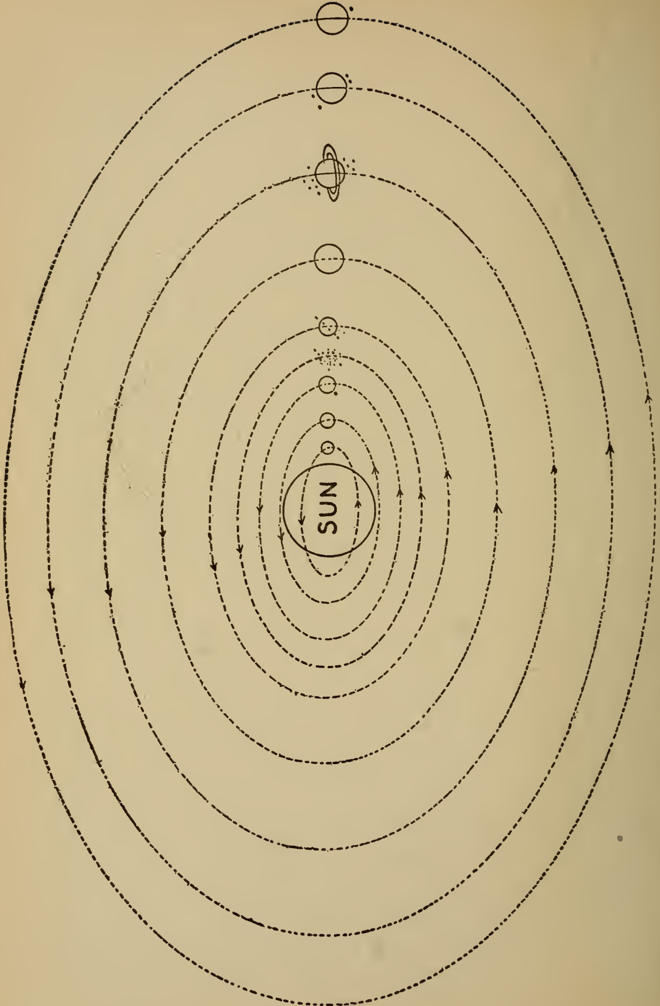


FIG. 62.—SOLAR SYSTEM IN PERSPECTIVE.

(Fig. 61) together, we shall have a picture of the *solar system,* as the Sun and all of his planets are called, as shown in Fig 62. From these pictures you will see that the planets have not been set around the Sun with any regard to their relative sizes.

To remember the arrangement of these planets in their relation to the Sun commit to memory this simple sentence:

Men Very Early Made Jars Serve Useful Needs.

As the first letter of each of the above words is the same as

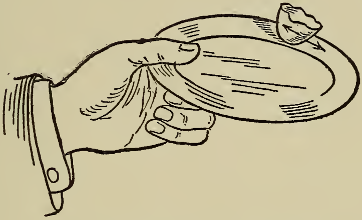


FIG. 63.—EGG SHELL ON PLATE.

the first letter of a planet, you will be able to instantly recall the proper place of any one of them.

How the Planets Are Held in Space.—If you will take an ordinary dinner plate and half an eggshell, and give the eggshell a slight spin on the rim of the plate—the rim should be slightly moistened—you will find that by tilting the plate a trifle the eggshell will revolve in two directions; first, it will spin round on its own axis, and second, it will travel round the rim of the plate, which we will call its orbit, as shown in Fig. 63.

This double motion of the eggshell is exactly like the double motion of a planet—each one turns on his own axis and each travels round the Sun in its own orbit; moreover, all the planets travel round the Sun in the same direction, the nearest planets taking the shortest time to complete the circle or orbit, while those farthest away take the longest time to go round their orbits just as we might expect them to do.

In the beginning of things the planets were a part of the

Sun, as we shall see further on, and when they were thrown off by him they spun round their own axes, and at the same time they shot out into space just like a ball spins round its axis as it leaves the pitcher's hand.

The force which causes the ball and the planets to turn on their *axes* while they are shooting off into space is called *centrifugal force.* Now, no one knows what centrifugal force

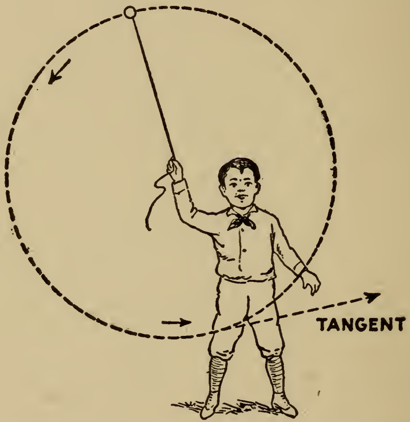


FIG. 64.—BOY THROWING STONE TO ILLUSTRATE CENTRIFUGAL FORCE.

is, but how it acts is very well known, and you can find out for yourself by making the following experiment:

Take a stone and tie one end of a string to it; now swing the stone round in a circle; if the string should break, or you should let it go accidentally (on purpose) the stone will shoot off at a *tangent,* that is in a line away from the circle in which it was swinging, as shown in Fig. 64.

This is just what the planets did when they were thrown off into space by the Sun, but they could not get very far away, for another force which is not only in the Sun but in every

particle of matter in the universe, pulled them back toward the Sun, just as it pulls a ball when thrown to the Earth, and this force is called *gravitation*.

So the centrifugal force keeps them spinning round on their axes and flying round in their orbits about the Sun. If it had not been for the attractive force of gravitation of the Sun and the planets, the planets would have kept right on going out into space and left the Sun to shift for itself forever after.

As it is they whirl round the Sun, never able to get any farther from him and yet never getting any nearer to him, for the centrifugal force tends to make them fly out and away and the force of gravitation tends to pull them back to the Sun. The result is that these two great opposing forces exactly offset or balance each other, and the planets are held in their orbits just as securely as the stone is held out by the force the boy exerts to move it, and in by the string he holds in his hand.

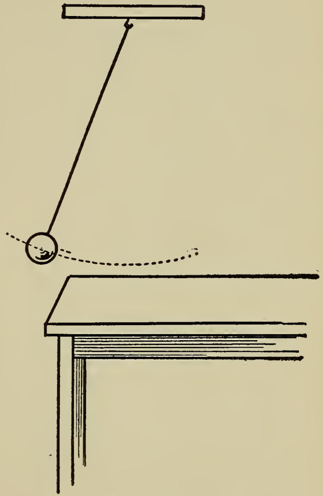


Fig. 65. — Iron Ball Pendulum Swinging in Straight Line.

This balancing of opposed forces was nicely shown some years ago by Sir Robert Ball, the great English astronomer, at one of his lectures in the Royal Institution of London, and I reproduce it here.

To the ceiling over his lecture table he had fastened a thin wire, the lower end of which was secured to a hollow iron ball. When the ball was pulled aside, it would swing like a great

pendulum, forth and back, in a straight line, as shown in Fig. 65.

But when a powerful magnet was placed on the table and the ball was set swinging in a straight line as before, just as it came close to the end of the magnet the latter pulled the ball with its mighty force toward it, and so changed its course, but the ball, instead of being attracted directly to it, swung in a graceful curve around it, as shown in Fig. 66.

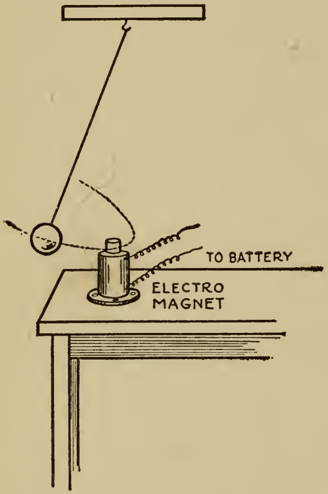


FIG. 66. — IRON BALL PENDULUM SWINGING IN CURVED LINE.

This is precisely the case of the planets swinging round the Sun, and shows very nicely the balanced forces of the Sun and the planets and why the planets stick to their orbits.

Why the Planets Do Not Stop Spinning.— Now you may ask why the planets do not stop turning on their axes and revolving in their orbits round the Sun. And the answer is because there is nothing to stop them.

If you spin a top on a plate it may keep going for a long time, but it will finally die down and stop. This is because there are other forces which oppose its centrifugal force. The forces a spinning top has to overcome are *friction* between the point of its spindle and the plate, and the *resistance* between the surface of the spinning top and the air pressing on its sides, and the friction and the air resistance together soon use up the energy stored in the top and which makes it spin.

But if you could spin and throw a top far enough away from the Earth so that it would not meet with friction or resistance of any kind, it would go on spinning forever just like the planets.

How to Plot the Position of a Planet.—One of the tests which a Boy Scout must pass in order to obtain a merit badge for starcraft is to "plot on at least two nights per month for six months the positions of all naked-eye planets between sundown and one hour thereafter. The plot of each planet shall contain at least three fixed stars with their names and designations, colors of planets and stars to be recorded by him."

Now, by looking at your almanac under the head of Morning and Evening Stars you will find all the planets which are listed as Evening Stars, together with the dates when they can best be seen. From your almanac for 1915 you will learn that

Mercury is an evening star, and can be seen about Feb. 5, May 31 and September 27 in the west, just after sunset; that

Venus will be an evening star from September 12 for the rest of the year; that

Jupiter will be an evening star until February 24; after that a morning star until September 17, and then an evening star for the rest of the year, and that

Saturn will be an evening star until June 28.

The first thing to do is to find what constellation is on your *meridian* at 9 P. M. for the month that the planet you wish to plot is to be seen. This you can do by looking at the map of the stars shown in Fig. 67. You can see any of the stars or constellations on your meridian by looking for them at 9 o'clock P. M. on the months marked above them.

This done, consult your almanac and find out what time the Sun sets on the day that the planet you are looking for can be seen.

As an example let's take Mercury, which the almanac says is an evening star about February 5, and which can be seen in the west just after sunset. The almanac will also tell you that the Sun sets on February 5 at 5 o'clock.

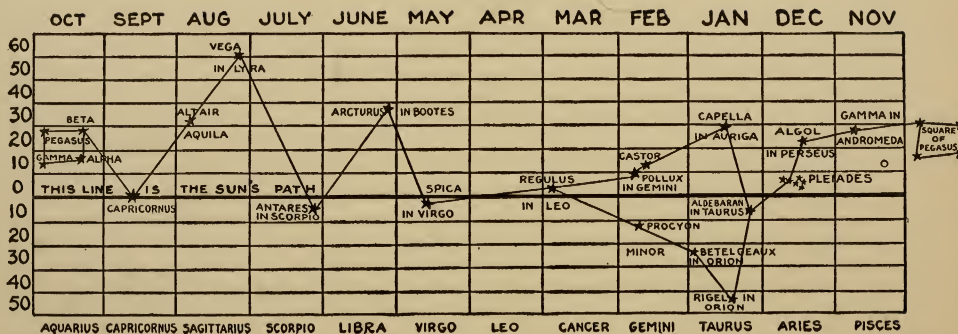


Fig. 67.—Map of Stars on Sun's Path.

The star map (Fig. 67) will show you that the constellation of *Gemini,* the Twins, is one which can be seen in February on your meridian at 9 o'clock at night, and you know that Mercury can be seen close to the western horizon from 3 to 4 hours earlier.

Since Gemini, the Twins, is on the meridian at 9 o'clock, *Taurus,* the Bull, which is the next constellation to it, will be on the meridian at 7 o'clock, and *Aries,* the Ram, will be on the meridian at 5 o'clock.

Now the next constellation to the west of Aries, the Ram, is *Pisces,* the Fishes, and the next one to Pisces, the Fishes, is

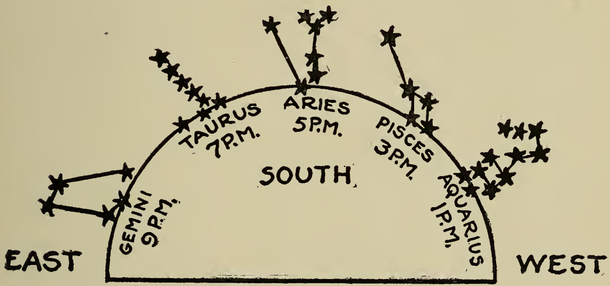


Fig. 68.—Diagram of Position of Constellations.

Aquarius, the Water Bearer, and as this constellation sets about an hour after the Sun, it is in this constellation that you will find Mercury in the early February evenings.

The diagram (Fig. 68) shows how it is that when Aries is on the meridian at 5 o'clock in the evenings of February, Gemini will be rising in the east, and Aquarius, with Mercury in it, will be getting ready to set in the west.

You can find all the other planets in the same way, but it is much easier to find them in the sky than it is to try and imagine their positions after reading how it is done. You should, though, by all means, read the chapter on *The Stars of the*

Zodiac before you try to plot a planet, for there is much useful information in it which you ought to know.

To plot the position of a planet, take a sheet of stiff paper or cardboard about 8 inches square and divide it into a square

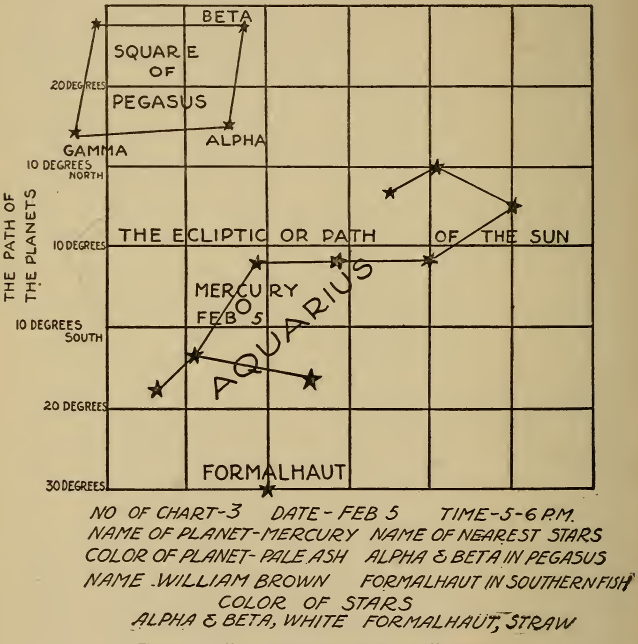


FIG. 69.—PLOTTING POSITION OF PLANET.

6 inches on the side, as shown in Fig. 69. This will leave a margin of 1 inch on both sides, ½ inch on top and 1¼ inches at the bottom of your paper.

Fasten the paper to your starboard, described in Chapter II, and go forth with it and your acetylene or flash lamp and find your planet. Having found it, mark with a pencil in the

squares on your ruled paper the positions of three of the nearest fixed stars which are shown in the star chart of Fig. 67. Now mark the position of the planet as you see it on your chart by making a little circle and your outdoor observation is ended.

Once inside mark down the chart number, the date and the time you made the observation; also the names and colors of the stars and the planet, and finish the record by signing your name. Should any of the other planets be visible at the time of your observation you will, of course, have to plot two charts, unless the planets are very near each other.

CHAPTER V

MOTHER EARTH, OLD ADAM'S PLANET

The Earth in the Making.—The Earth on which we live and find so much that is interesting was once a part of our Sun just as the other planets were.

When the Sun was being made of star stuff great quantities of gases were set into mighty whirls, and when these acquired enough force they shot off into space like so many cannon balls, and they are still a-whirling.

But these new-born planets could only get a certain distance away from the Sun, as we have learned, for the force of his attraction offset the force of their motion with the result that they are still held in space around him.

One of these whirling bodies was the Earth, and when it had comfortably settled in its orbit and slowed down a bit it began to cool off and a crust was formed on its liquid surface, just as ice is formed when water is frozen. Then some of the gases condensed into water and others became air and when the Earth had cooled down still further some millions of years afterward it became a more or less suitable place for human beings to live on.

While the Earth has cooled off until it is possible for us to live comfortably on its crust, it is still warm outside and very hot inside. This is proved by volcanoes which throw out white-hot lava and gases when they are in eruption.

If it had not been for the light and heat of the Sun in the past ages there never could have been any kind of life on the Earth. The Earth is just as dependent on the Sun now as it was in the past, and if he should fail to shine on our world for

even a little time everything would die. Fig. 70 is a cross section of the Earth.

To Prove the Earth is Round.—Every boy knows that the Earth is round, but the wisest of men did not know it for certain until about 400 years ago, when one of Magellan's ships

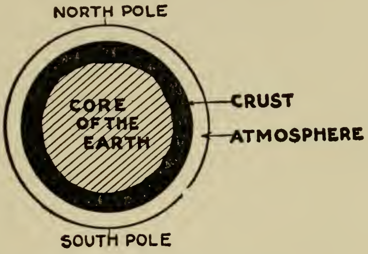


Fig. 70.—Cross Section of the Earth.

made a complete voyage round the world and returned to the place she started from.

(1) One of the easy ways to show that the earth is round, or at least that the surface of the earth is curved, as shown in Fig. 71, is to watch a ship as she sails out to sea. All of the

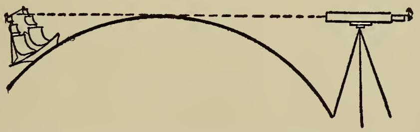


Fig. 71.—Sails of Ship Can Be Seen After Hull Has Disappeared.

ship—hull, sails and smokestack, if she has one—can be seen until she sails over the horizon, and then her hull, which is the largest part of her, is lost to view, then her sails and stack, and finally only the tops of her masts can be seen. It is a pretty good sign that the Earth is a ball.

(2) A very pleasant way to prove the Earth is a ball is to

take passage on a ship that makes a round-the-world cruise. If you leave New York and keep sailing east all the time you will finally land at San Francisco; keep on going east by rail and you will find yourself back in dear old New York, where you started from, having gained a day on the way. See Fig. 72.

To Prove the Earth Turns on Its Axis.—(1) Having proved that the Earth is round, the next thing to do is to prove that it turns about on its axis.

(1) The best known experiment for showing that the Earth really turns on its axis was made by Foucault (pronounced Foo-ko′), a French philosopher, in 1851, who used a pendulum for the purpose.

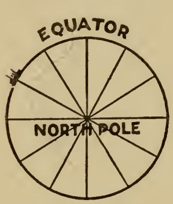


Fig. 72. — Sailing Round the Earth.

In the top of a great dome in a building in Paris, called the *Panthéon,* Foucault hung a large metal ball by means of a wire about 150 feet long. On the floor he made a mark, exactly under the ball, running due north and south. Then drawing back the ball, he let it go, when it swung directly over the line.

The heavy pendulum, which after being started swung for hours, seemed to move away from the line toward the west, but, instead, it was the Earth which was really turning round under the swinging pendulum. Fig 73 shows how the line on the floor moved with the Earth from under the ball. You can repeat the experiment if you can get a heavy ball and a place high enough to fasten a wire 30 or more feet in length.

(2) A much simpler way to show the turning of the Earth on its axis, though this experiment does not show the Earth's motion as clearly as the pendulum, is to make a photograph of the North Star and the stars in its neighborhood, as explained in Chapter XII.

During the time the sensitive plate is being exposed the camera will be carried round by the Earth turning on its axis and the fixed stars will leave bright trails on the plate in *arcs of circles.*

The Earth Turning on Its Axis Makes Day and Night.—The Earth, in turning round on its axis once every 24 hours, receives the light of the Sun on half of its surface at a time, making the day, while the other half is in the shadow, which makes the night.

If the equator of the earth was in a plane with the Sun, as shown in Fig. 74, it is easy to see that the days and nights

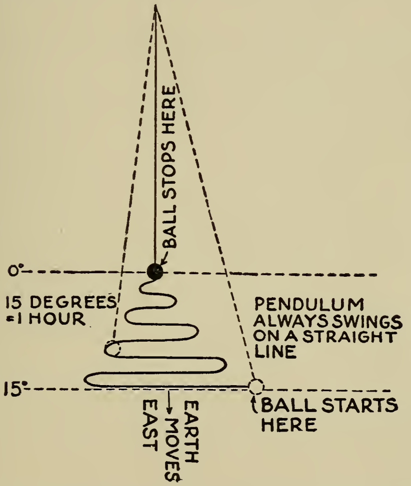


FIG. 73.—THE EARTH MOVES AWAY FROM THE SWINGING PENDULUM.

all over the world would be of the same length, that is, each would be 12 hours long. Instead, the Earth tilts a little, as shown in Fig. 75—to be exact, its axis tilts 23½ degrees out of the *perpendicular* and this makes the day and the night at the equator each 12 hours long and the day and the night at the north and south poles each six months long.

The line round the Earth which is in a plane with the Sun is called the *ecliptic,* and for this reason the Sun seems to follow

a path round the Earth that is in a line with the ecliptic, and this is called the *path of the Sun.*

To Show That the Earth Travels Round the Sun.—When we look at the Sun and the stars it is hard to believe that they

FIG. 74.—IF THE EARTH'S EQUATOR WAS IN A LINE WITH THE SUN.

are standing still and that it is the Earth which is whirling round on its own axis and also round the Sun.

We have given a couple of experiments to show that the

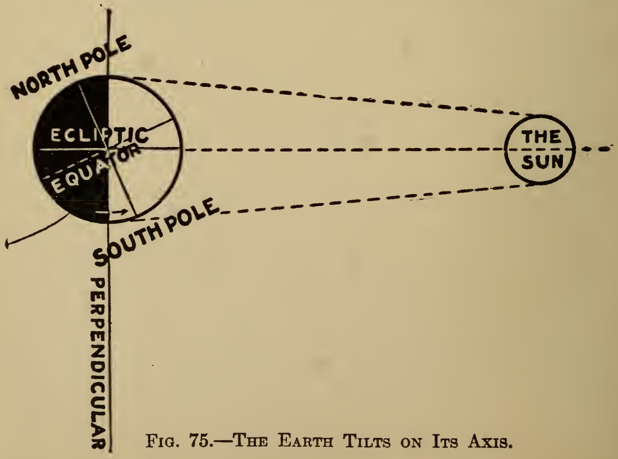


FIG. 75.—THE EARTH TILTS ON ITS AXIS.

Earth turns on its own axis, and here is one to show how the Earth travels in a great circle, or rather *ellipse,* round the Sun and gives us our year.

It does more, for the Earth being tilted off the perpendicular, its movement round the Sun causes the north pole to be turned toward the Sun half of the time, and then the south pole to be turned toward the Sun an equal length of time, which

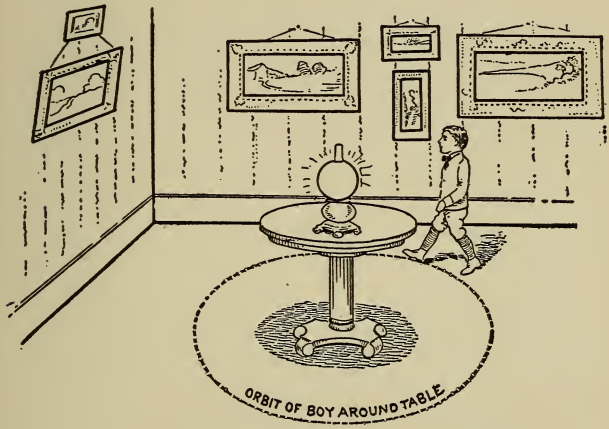


FIG. 76.—LIGHT IN ROOM TO REPRESENT SUN.

gives each of them a day and a night that is six months long.

In the center of a large room set a light so that it will be about as high as your eyes. Let this light represent the Sun; you must play now that you are the Earth, and think of the pictures on the wall as being the stars fixed in the sky away off in space. Now walk in a circle around the light toward the right and facing the light all the time. As you move around the light you will see that it *seems* to move with you in a circle and also that it *seems* to move past the pictures on the wall. The experiment is shown in Fig. 76.

This, then, is exactly what happens when we look at the Sun and the stars. The Earth moves round the Sun in a circle, nearly, and since the Sun is so much closer to us than any of the other fixed stars the Sun apparently moves by the stars, because the Earth changes its position relative to it and the stars.

The Earth Turning Round the Sun Makes the Seasons.—We have seen how the days and nights would be equal all over the world if the equator of the Earth was in a plane with the Sun, but since the Earth is tilted the days and nights are unequal except twice a year, and this is when the places where the *ecliptic* and the *equator* cross each other are facing the Sun.

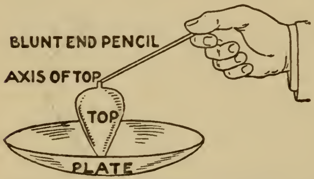


Fig. 77.—Top Spring on Plate.

Again, if the Earth's equator was always in a plane with the Sun the light and heat would be about the same all over the world and there would be no seasons. But the Earth having its axis tilted, and which is always set in the same direction, together with the Earth speeding in a circle around the Sun, causes some curious things to happen and the seasons are one of them.

To make clearer the reason the axis of the Earth always stays in one position take a top and give it a good spin. The top, of course, turns round its axis very fast, and this is like the Earth turning round its axis every 24 hours.

Now, if you place the blunt end of a pencil on the upper axis of the spinning top, as shown in Fig. 77, and try to tilt it in some other direction than that it took when it began to spin, you will find it rather a hard thing to do. In other words, once a body is rapidly turning on its own axis it very strongly tends to keep its axis pointing in the same direction.

This rule also applies to the Earth, for having been tilted at an angle when it was thrown off by the Sun in the making, no other forces have ever been able to change the position of

its axis to any great extent, though the Earth spins easily on its axis and also revolves round the Sun.

To understand how the seasons are made you must first have clearly in mind the positions of the tilted Earth in different parts of its orbit round the Sun. The things needed for this experiment are a nice round apple, a candle, a piece of string, a safety pin and a knitting needle.

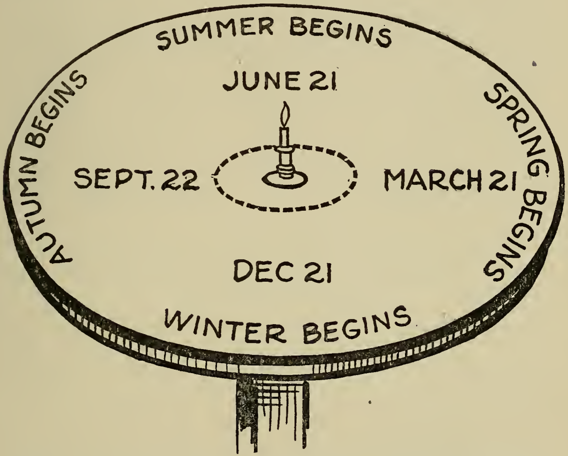


Fig. 78.—Circle Around Candle Marked with Seasons.

Place the candle in the center of a table and call it the Sun; draw a circle a foot in diameter on the table top and around the candle with a bit of chalk. Mark one side September 22; at the next quarter of the circle mark December 21; directly opposite the September mark chalk in March 21, and finally between March and September mark June 21, all of which is shown in Fig. 78.

Push the knitting needle through the center of the apple, call the apple the Earth and call one end of the knitting needle

the north pole and the other end the south pole. Fasten the safety-pin through the skin of the apple and tie the string to

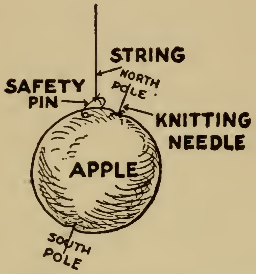


FIG. 79.—APPLE TO REPRESENT EARTH SUSPENDED IN AIR.

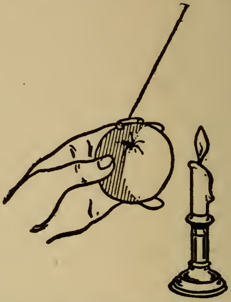


FIG. 80.—POSITION OF THE EARTH AND SUN IN AUTUMN.

the pin so that when the string is tied to a tack in the ceiling or some one is holding it directly over the candle the knitting

FIG. 81.—POSITION OF THE EARTH AND SUN IN WINTER.

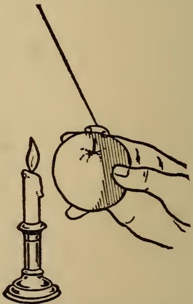


FIG. 82.—POSITION OF THE EARTH AND SUN IN SPRING.

needle of the apple will be tilted to the perpendicular, as shown in Fig. 79.

Now grasp the top of the needle, which is the north pole,

with the left hand and hold the apple away from the candle, as shown in Fig. 80. This is the position of the earth to the Sun on September 22, when the Sun passes directly over the Earth's equator, and for us autumn is at hand.

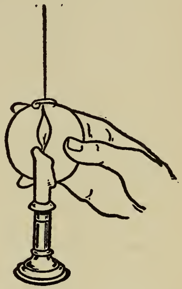


Fig. 83.—Position of the Earth and Sun in Summer.

Now pull the apple by its north pole toward you and around one quarter of the circle chalked on the table, as shown in Fig. 81, which is the position of the Earth to the Sun on December 21. You will see that the north pole is away from the light and heat and hence it is dark and winter there; but the south pole on the other end is getting plenty of light and heat and it is both day and summer there. This marks the beginning of our winter.

Push the apple by its north pole—always being careful to keep the knitting needle tilted in the same position—around

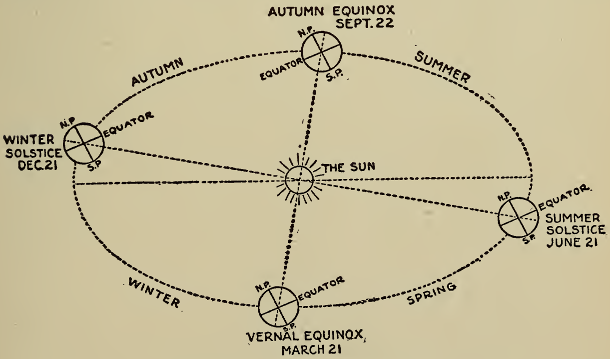


Fig. 84.—Cycle of Seasons.

another quarter of a circle and this is where the Earth is in its orbit, and its position to the Sun on about March 21. Once

again the Sun is over the Earth's equator and all parts of our world are then lighted and heated equally, and we have the beginning of spring. See Fig. 82.

Again push the apple around another quarter circle and June 21 is reached. This time you will find the north pole is turned toward the Sun and this time it gets the light and heat for six months, while the south pole is away from the Sun and takes its turn of six months of night and winter. To us, however, it is the beginning of summer. Fig. 83 shows the position of the Earth to the Sun at this time.

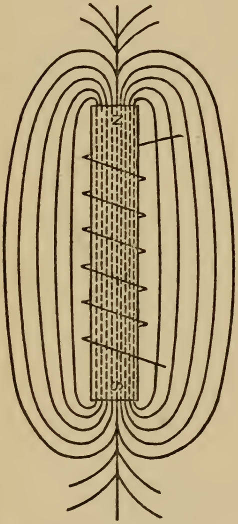


Fig. 85.—Lines of Force through and around a Magnet.

Pull the apple one more quarter of the circle round the candle and you will have completed its orbit just as the Earth swings round the Sun in 365 days. The seasons are more clearly shown in Fig. 84.

The North Pole. — The north pole is not only one of the ends of the axis round which the Earth turns but close to it is the *north magnetic pole* as well. By *magnetic* we mean that the Earth behaves like a steel bar that has been magnetized.

A steel bar magnet like that shown in Fig. 85 is strongest at its ends. One end is *positively* magnetized, and we call this end its *north pole,* and the other end is *negatively* magnetized, and we call this end its *south pole.*

Magnetic lines of force stream from the south pole through the steel bar and reaching the north pole they stream through the air to the south pole, as shown by the curved lines, thus

forming a *magnetic circuit*, just as two wires joined together may form an electric circuit.

If we place a compass needle near the steel bar magnet the needle will turn in the same direction as the magnetic lines of force are flowing, and it will, therefore, point to the north and to the south poles of the magnet.

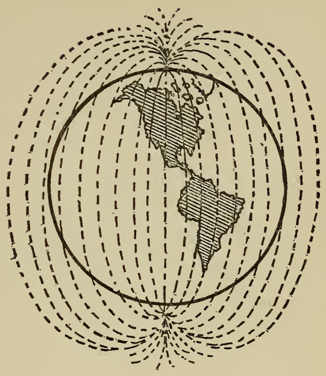


Fig. 86.—Lines of Force around the Earth.

Now the Earth is a great magnet with a positive pole, which we call the north pole at one end of its axis, and a negative pole, which we call the south pole, at the other end of its axis, as shown in Fig. 86.

Fig. 87.—Watch Spring—Needle for Compass.

Like a bar magnet, magnetic lines of force stream all over the Earth's surface from the north pole to the south pole, and a compass needle placed anywhere on the Earth will swing round until it is in the same direction as the lines of magnetic force.

How to Make a Simple Compass.—Take a piece of watch spring about 3 inches long and straighten it. Heat the middle red-hot and let it cool slowly, when the temper will be taken out of it at this point. Place a center punch in the middle of the spring and strike it a sharp blow with a hammer; this will make a little dent in it. Bend it as shown in Fig. 87. To magnetize the needle rub one end on the north

Fig. 88. — Compass Complete.

pole and the other end on the south pole of a steel magnet. Stick a sewing needle into a large cork and lay the magnetized needle on it, when it will point north and south, as shown in Fig. 88.

Boxing the Compass.—There are two kinds of compasses in general use, though both kinds use a magnetized needle. The first kind is the ordinary pocket compass, with either a pull-off cover or one of the watch-case pattern. In this kind of a compass the magnetic needle is fitted with a jeweled center which swings on a steel needle; the dial is fixed in the case and is marked with the *cardinal points,* that is with the chief points of a compass. Fig. 89 shows a pocket watch-case compass.

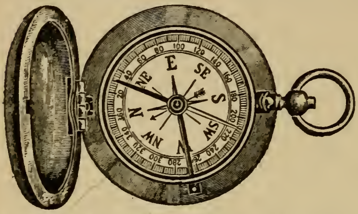


Fig. 89.—Pocket Watch-case Compass.

In the mariner's compass, which is used at sea, the compass card and the magnetic needle are fastened together. The card is made of a circular sheet of mica and the points of the compass, which are called *rhumbs,* are marked on the edge. The needle and card float in a bowl of mercury.

Fig. 90.—Dial of Mariner's Compass.

The card is marked with 32 *rays,* forming a many-pointed star, and each of these points has a name, the names of the four *cardinal points* being *north, east, south* and *west.* To know

all of the points by heart and be able to name them, beginning with the north and going round the card to the north again, is what sailors call *boxing the compass.* See Fig. 90.

Points on Compass Card	Names of Points
N	North
N bE	North by east
NNE	North, northeast
NE bN	Northeast by north
NE	Northeast
NE bE	Northeast by east
ENE	East, northeast
E bN	East by north
E	East
E bS	East by south
ESE	East, southeast
SE bE	Southeast by east
SE	Southeast
SE bS	Southeast by south
SSE	South, southeast
N bE	South by east
S	South
S bW	South by west
SSW	South, southwest
SW bS	Southwest by south
SW	Southwest
SW bW	Southwest by west
WSW	West, southwest
W bS	West by south
W	West
W bN	West by north
WNW	West, northwest
NW bW	Northwest by west
NW	Northwest
NW bN	Northwest by north
NNW	North, northwest
N bW	North by west
N	North

DIAL OF A MARINER'S COMPASS

How to Make a Simple Dipping Needle.—When a compass needle is pivoted so that it can swing up and down, that is, to and away from the earth, it is called a *dipping needle.*

Such a needle will dip toward the nearest pole of the earth.

At the equator there is no dip, that is, the needle will stand *parallel* with the Earth's surface.

At the north pole the needle will stand straight up and down in a line with the axis of the Earth. The dip, therefore, of the

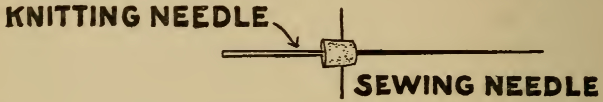


FIG. 91.—NEEDLE FOR DIPPING NEEDLE.

needle at any place on the Earth's surface is just about that of the latitude of the place where it is used. Dipping needles are also used by miners for finding iron ores.

To make a dipping needle, slip a small cork over a knitting

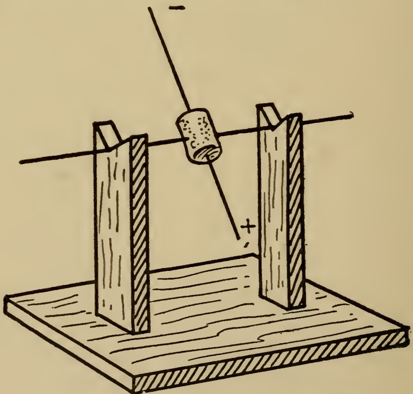


FIG. 92.—DIPPING NEEDLE COMPLETE.

needle and push a sewing needle through the cork at right angles to the knitting needle, as shown in Fig. 91. Now lay the sewing needle with its ends on the edges of two tumblers, and see that the knitting needle is perfectly balanced. This done, mag-

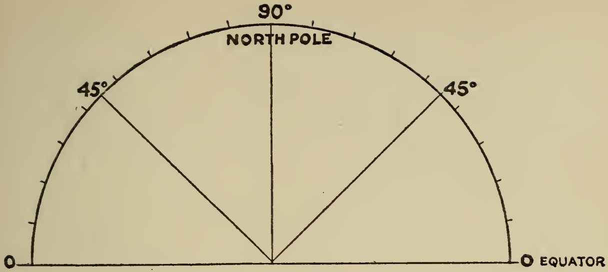


Fig. 93.—Protractor Showing Degrees.

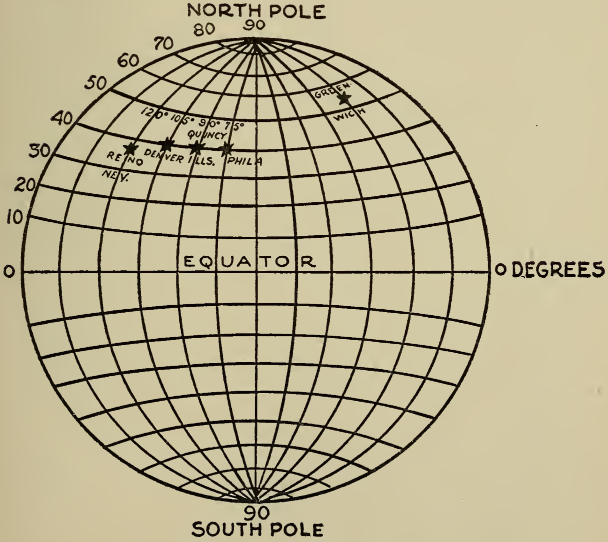


Fig. 94.—Earth Surface Divided into Degrees.

netize the knitting needle by rubbing one end on the north pole of a steel magnet and the other end on the south pole of the magnet. Make a little wood stand as shown in Fig. 92 and place the ends of the sewing needle on the wood supports.

The latitude running through the middle of the United States is about 40 degrees north of the equator and if you live

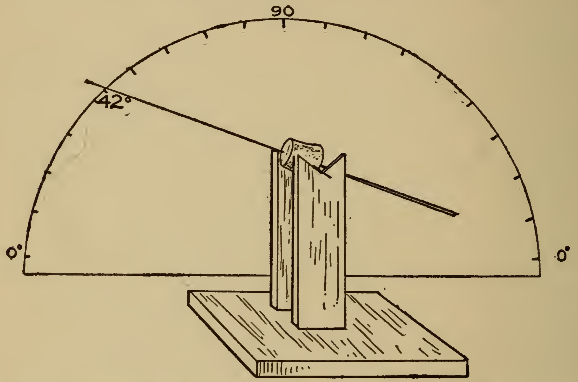


FIG. 95.—PROTRACTOR SET BY DIPPING NEEDLE SHOWING LATITUDE.

in this latitude the dip of your needle will be about 40 degrees from the horizontal.

How to Find Latitude.—The *latitude* of a place on the Earth's surface is its distance north or south of the equator. This distance is usually measured in *degrees* of a circle, instead of in miles.

The equator is called 0 (zero) degrees, and the north and south poles are 90 degrees from the equator, as shown in Fig. 93. If you are in Philadelphia, Pennsylvania, or Quincy, Illinois, or Tehama, California, you are in latitude 40 degrees. If you are in Bangor, Maine, St. Paul, Minnesota, or Portland, Oregon, you are in latitude 45 degrees, or just halfway between the north pole and the equator, as Fig. 94 shows.

(1) An easy way to find roughly the latitude of a place, that is, its distance from the equator, is to use a dipping needle and a *protractor.*

To make a protractor cut out a semi-circle of stiff, white cardboard, just the size shown in Fig. 93, and mark the figures on the edge and draw lines from the edge to the center point exactly as in the picture.

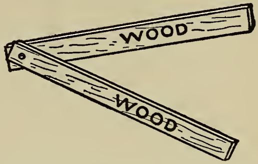


FIG. 96.—TWO STICKS SCREWED TOGETHER.

Now place your dipping needle on a level board or table and set your cardboard protractor by the side of it, as shown in Fig. 95. Whatever line on the protractor the dip of the needle takes the degree marked on the edge of the protractor will be about the latitude you are in.

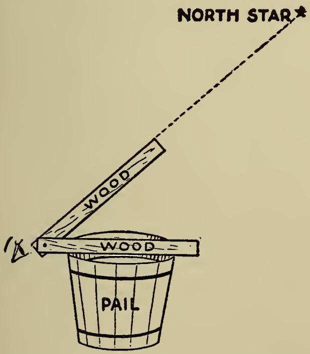


FIG. 97.—TWO STICKS ACROSS BUCKET OF WATER.

(2) Another way to obtain latitude is to take two smooth pieces of wood, about 1 foot long and ¼ inch thick, and hinge them together at one end with a screw, as in Fig. 96. Now set a bucket out-of-doors in an open space from which the North Star may be seen, fill the bucket with water and level it up until the water is parallel with the rim all the way round.

When night falls find the North Star and set your sticks across the rim, as shown in Fig. 97. Raise one of the sticks and sight it until it points straight at the North Star, and having done this you are through with the observation.

Take the sticks into the house, being very careful not to

change their relative positions, so that the *angle* they form can be measured with a protractor. Tack a piece of paper on your starboard and draw a straight horizontal line on it.

Lay the stick that was on the bucket on the horizontal line, and draw a line along the edge of the other stick with which you sighted the North Star, as in Fig. 98.

Now measure the distance, in degrees, between the two lines with your protractor and the number of degrees you get will be roughly the latitude.

Shooting the Sun.—Another and very exact way to find the latitude, and which is also used to help find longitude when

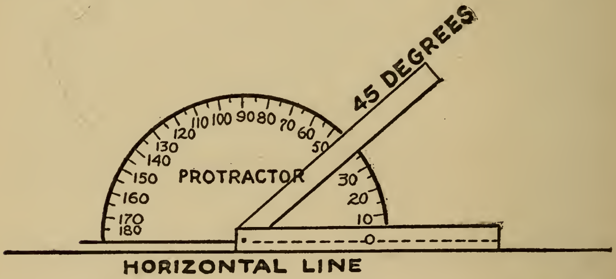


Fig. 98.—Protractor and Sticks on Drawing Paper.

at sea, is by means of an instrument known as a *sextant*, so called from the fact that it is formed of a sixth part of a circle.

It is made with a metal frame A and having the degrees marked on its curved edge B like a protractor. On one end of a thin strip of metal, or arm, C (see Fig. 99), a mirror, D, called an *index mirror*, is rigidly fastened, and right under the center of this mirror the arm C is hinged to the frame A. The other end of this arm slides over the scale B.

To the left side of the frame also rigidly fastened is a second glass E called a *horizon glass*, and half of which is clear and half silvered. A *telescope* is also rigidly fastened to the frame A directly opposite but in a line with the horizon glass E.

Now to find the latitude by *taking the Sun,* or as sailors sometimes call it, *shooting the Sun,* in order to learn the position of the ship at sea, the sextant is held in both hands firmly, and the horizon which is sighted through the telescope is brought into view through the clear part of the horizon glass E.

The arm C, carrying the index mirror D, is now moved over the scale A until the light from the Sun just as it crosses the meridian at noon is reflected by its polished surface into the silvered part of the horizon glass E, and this reflects the sunlight into the telescope right in a line with the line of sight to

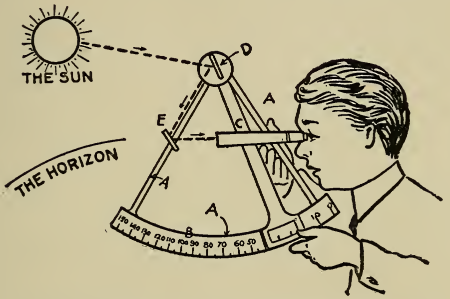


FIG. 99.—SEXTANT IN USE. SHOOTING THE SUN.

the horizon. This forms an angle of the two beams of light just as an angle is formed of the two sticks of wood in the pail experiment and the number of degrees the end of the arm C points to on the scale B is the latitude in degrees or the distance of the ship north or south of the equator.

How Longitude is Found.—To find the longitude at sea, that is, the position of a ship east or west of a given place, is just as simple a matter as finding the latitude or its position north or south of the equator. Two instruments are used to find longitude, and these are the sextant, which has just been described, and a very accurate clock, called a *chronometer* (pronounced chro-nom′-e-ter).

As you know, imaginary lines running from the north pole to the south pole are called *meridians of longitude.* Now the Earth has been divided into 24 of these lines, the zero meridian, from which distances east and west are measured, running through Greenwich, England.

There are 24 of these *standard meridians* and hence they are 15 degrees apart—since there are 360 degrees in a circle—and they are 1 hour apart—since there are 24 hours in a day, and therefore 15 degrees equal 1 hour. (See Chapter X, *The Time o' Day.*)

Now, since it is 12 o'clock noon when the Sun passes over any one of these standard meridians, it will be 11 o'clock A. M., 15 degrees west of it, and 1 o'clock P. M., 15 degrees east of it, and consequently there will be an hour's difference in the time, either fast or slow, for every 15 degrees, depending on whether you count east or west from the noon meridian.

The purpose of a sextant in finding longitude on shipboard is to know when it is exactly noon by the Sun, and in this way the *local time* is found. The purpose of a chronometer is to carry exact Greenwich time, and the difference between the *local time* found each day by taking the Sun, and *Greenwich time* shown by the chronometer gives the distance in degrees the ship has traveled from Greenwich.

By knowing the latitude and longitude of a ship the distance in miles north and south and east and west from any port can be figured out without much trouble.

The reason that a very accurate clock has to be carried is that a difference of a few seconds either too fast or too slow will affect the calculations just that much, and this means that the ship will be thrown out of its calculated position by several miles.

To correct the observations with the sextant and the inaccuracy of the chronometer, etc., are a part of the business of the navigating officer, and he is provided with tables and things to make this work as easy and certain as is possible.

How to Know When You Are at the North Pole.—If you should ever reach the north pole where overhead is north and every other direction is south how would you know it?

Suppose you were standing on the exact top of the world during one of its long polar nights, then the North Star would be directly over your head and the Big Dipper and Cassiopeia would serve to mark the passing of days as well as of nights, that is, if you were at the north pole in the wintertime.

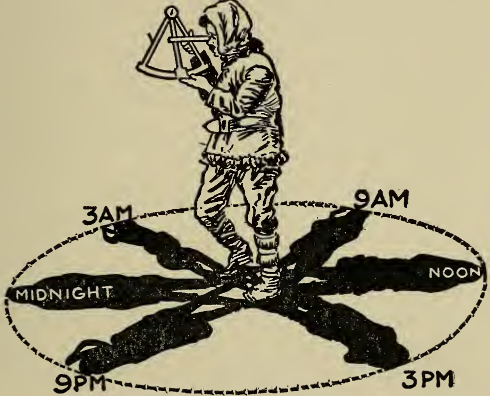


Fig. 100.—Shadows at the North Pole.

But if you were there during a long Arctic day, that is, in the good old summertime, you could see the Sun making a great circle, or seem to, once in 24 hours, always keeping the same position, and never going higher or getting lower.

Explorers use a sextant to find out when they are at the north pole, and they sight the Sun's height above the horizon at morning, noon and night. If the angle the Sun makes with the horizon is the same every time he is observed, the explorer knows he is standing on the very point round which the Earth turns. Then he plants a stick in the snow and ice on the north pole,

hoists the American flag, and hurries home as fast as dogs and ships and trains can carry him to tell about it.

If you ever reach the north pole you can know it, too, even though you haven't a sextant with you. All you need to do, when you think you are standing on the north pole, is to notice the length of your shadow five or six times in 24 hours. If the length of your shadow is exactly the same every time you look at it, as shown in Fig. 100, you are really and truly at the north pole.

Difference Between the True North Pole and the Magnetic North Pole.—The compass and dipping needle do not point to the *true north pole,* for the *magnetic north pole* and the true north pole are not located at the same place.

The magnetic north pole was found by Captain Ross in 1832. At that time the magnetic north pole was northwest of Hudson's Bay in about latitude 70 degrees north and longitude 96 degrees and 45 minutes west, that is, west of the zero meridian which runs through Greenwich.

CHAPTER VI

THE MOON, THE EARTH'S DAUGHTER

How the Moon Was Made.—There was a time away back in the beginning of the planets when the Earth did not have a Moon.

Two ideas have been worked out to account for the birth of the Moon and these are somewhat alike, for both agree that just as the Earth was once a part of the Sun and was whirled

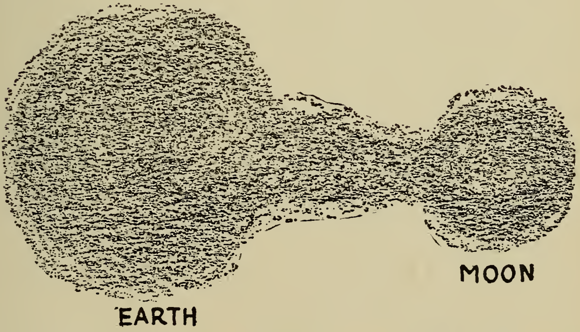


Fig. 101.—Moon and Earth Joined Together Like a Dumbbell.

off into space and became a planet so the Moon was once a part of the Earth and was thrown off and became her daughter.

The first idea as to how the Moon was made is that a smaller core was formed in the gaseous matter of the Earth and that this core and the core of the Earth, which were at first joined

together like a dumbbell, as shown in Fig. 101, began to spread apart like a pair of balls fastened together with a piece of elastic when they are whirled rapidly round each other, as shown in Fig. 102.

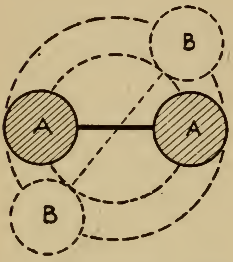


Fig. 102. — Balls Connected with an Elastic.

So, too, the high speed with which the Earth turned on its axis when it was in the making caused the smaller part to fly off its handle and it became the Moon.

The second idea is like the first, except that the Earth is thought to have cooled down until it was a melted mass, and it was then that a great upheaval took place in which a part, one-eightieth as large as that of the world itself, was torn out of its side and, whirling away by centrifugal force, the Moon was born.

To throw off such a mighty part of its bulk as the Moon, it has been figured out that the Earth must have made a complete turn on its axis every 2 hours, instead of one turn in 24 hours, as it now does; and it was while the Earth was turning at this terrific rate of speed that the centrifugal force overcame the force of gravitation and tore the Moon from the Earth's side and formed a little world of its own.

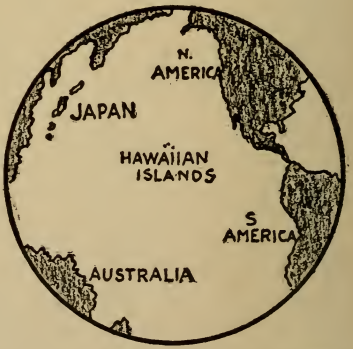


Fig. 103.—Map Showing Pacific Ocean.

It is believed by some astronomers that the Moon was once that part of the Earth which is now filled up by the waters

of the Pacific Ocean and there are several reasons why this seems very likely.

First, if the waters which form the Pacific Ocean were rolled into a big ball it would be just about the size of the Moon; second, the space between the coasts of North and South America on the east, and Asia and Australia on the west, will be seen by referring to Fig. 103 to be roughly circular in form; third, there is a marked likeness between the volcanoes in California, in the Hawaiian Islands and in Japan to those on the Moon;

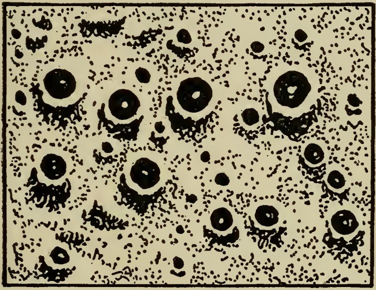


Fig. 104.—Imitating the Volcanoes in the Moon.

and fourth, the Hawaiian Islands seem to have been the axis or hub round which the melted mass forming the Moon began to spin until it became a ball, when the combined action of the Earth's centrifugal force and the Sun's attraction caused it to fly away.

It was, doubtless, at this long ago time that the great volcanoes of the Moon, as well as those of the coasts of and on the islands in the Pacific Ocean were made, but what caused them can only be guessed at. There are two ideas, also, to account for them; one is that the pent-up gases inside the Earth and the Moon exploded and so threw up the volcanoes; the other idea is that showers of gigantic melted masses fell on the surface of both the Earth and Moon and so caused them.

An experiment to show how the volcanoes might have been formed by showers of meteors can be made by covering the surface of your starboard with a layer of soft clay about 4 inches thick, and then throwing clay balls against it. Artificial volcanoes with craters and all will result as shown in Fig. 104. Compare this picture with that of Fig. 105, showing the real volcanoes on the Moon, and you will see they are quite alike.

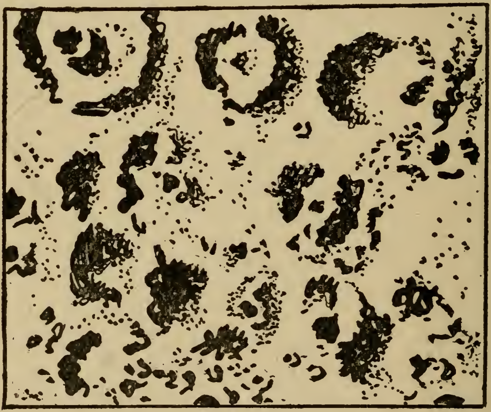


Fig. 105.—Real Volcanoes.

The volcanoes of California, Japan and the Hawaiian Islands are, many of them, still active, while those on the Moon have long since become extinct. This is easily accounted for, since the mass of the Moon is very small compared with that of the Earth, and hence, the Moon has cooled off more quickly than the Earth. The result is that while the Earth is yet hot and teeming with life and activity, the Moon is cold, and dead and silent.

Seeing the Moon With the Naked Eye.—If you look at the full Moon with the naked eye it will appear as a great, silvery-bright disk, and about the same size as the Sun.

Look again and you will see that some parts of it are much brighter than others, while another and closer observation will show you that the light and shaded parts take on the expression of a man's face, as shown in Fig. 106. This is the famous *Man in the Moon,* and once you make out the likeness you will never again be able to look the full Moon in the face without seeing the man in it.

When we look at the Moon we always see the same side of it, which will be readily understood when we come to the turning of the Moon on its axis. As the Moon revolves about the Earth, you will see, if you look toward the west at the right time of the month, just at dusk, a pale *crescent* of light, and very soon after the Sun sets it drops out of sight below the horizon.

Fig. 106.—Naked Eye Drawing of Full Moon.

A few nights later the Moon will be seen, over in the sky toward the east; its crescent shape grows into the first quarter, and the Moon looks as if it was split in two. As the nights go by the Moon *waxes* until it is *gibbous* and finally the full Moon—with the man in it—stands out round and clear and bright.

It is a good idea at this time, that is, when the Moon is full, to make a drawing of her face, and the best time to do it is shortly after twilight, for later in the evening the Moon is so bright it is hard to see the details. After this the Moon begins to *wane;* it again becomes gibbous; then reaches its last quarter later only a crescent can be seen, and she finally disappears.

At other times when the crescent is bright the whole dark disk of the Moon can be seen glowing dimly with a reddish, copper color, and this is called the *old Moon in the new Moon's arms.* This copper-colored glow is the *Earth-shine* on the Moon, that is, the sunlight on the Earth, which is reflected to the Moon and back again to us.

On one side of the Moon you may be able to see a dark oval

spot which is marked *Grimaldi* on the maps of the Moon. Grimaldi is a great plain, having nearly 14,000 square miles in it, with mountains flanking it on the sides. This is another good eyesight test, for it takes a mighty sharp eye to see it without a glass.

These and a dozen other interesting things on the Moon can be seen without a telescope.

The Motions of the Moon.—The Moon turns round on its axis once every month and it also revolves round the Earth once every month, so that the Moon's day and year are of the same

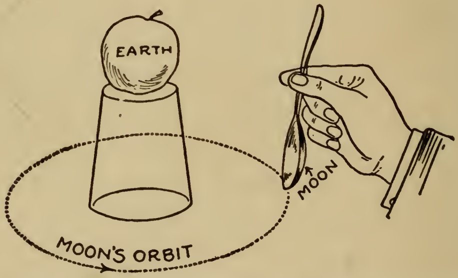


Fig. 107.—The Experiment Showing How One Revolution of the Moon round the Earth Makes it Turn Once round its Axis.

length just like Mercury and Venus, and this is the reason that one side of the Moon is always turned toward the Earth, as you will see if you look at her through a glass.

A simple experiment will show the cause of this: Place an apple, which we will call the Earth, on the bottom of an inverted glass on a table, and draw a chalk circle a foot in diameter around it. Next, take a tablespoon to represent the Moon, and hold it upright with the point of its bowl on the chalk line and with the bowl turned toward the apple, as shown in Fig. 107. Now, draw the spoon round the circle, turning it in your fingers so that the bowl is always toward the apple.

It is easy to see that in order for the bowl of the spoon to be turned toward the apple during all of its travels round the chalk circle the spoon must also turn once round on its own axis, and this is the reason we always see the same side of the Moon.

The Moon's Phases.—Since one side of the Moon is always turned toward the Earth, it is clear that this is the only side

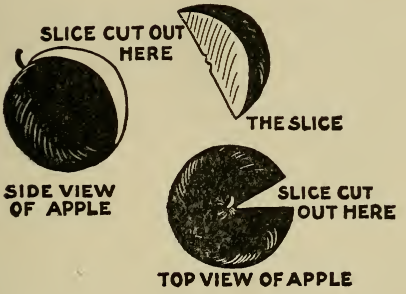


Fig. 108.—Apple Cut to Show Crescent.

we can ever see, and, further, we are only able to see all of this side part of the time.

The different *aspects* we get of the Moon as it revolves round the Earth are called the *Moon's phases;* and each phase has a name, as the *new moon;* the *first quarter;* the *full moon,* and the *last quarter.*

Between the new Moon and the first quarter, and between the last quarter and the new Moon only a crescent, or sickle-like edge of the Moon, can be seen; while between the full Moon and last quarter the Moon is gibbous (pronounced gib′-us and meaning swelled, or shaped like a football).

If you will look at the picture, Fig. 108, and the diagrams, Figs. 109 and 110, and do the experiment which follows, the way the phases of the Moon are made will be perfectly clear.

The picture, Fig. 108, shows an apple from which a thin

sector or slice has been cut. The lower picture shows the stem end of the apple and from this point of view the part where the slice was cut out looks wedge-shaped. This is the view of the Moon shown in Fig. 109, if we could look down on it.

Now turn the apple on its side and the place where the slice was cut out can be seen from the stem to the blossom end of

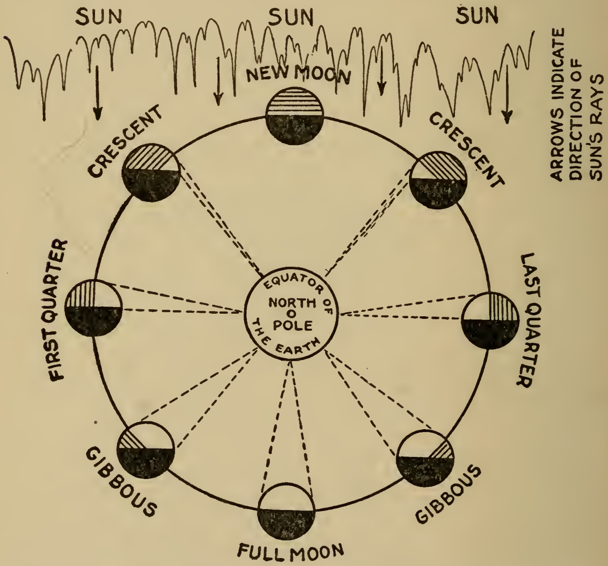


Fig. 109.—Diagram Showing How the Moon's Phases Are Made.

the apple when it takes on a crescent form. This is the view of the Moon we really get between new Moon and its first quarter, as shown in Fig. 110.

The diagrams, Figs. 109 and 110, show the Earth in the center of the Moon's orbit and the Moon is pictured in eight positions, as it moves round the Earth, one for each phase, while

the sunlight falling upon the Earth and the Moon is shown by streamers of light from the Sun above.

The diagram, Fig. 110, shows how the sunlight falls on the Moon, but you must always keep in mind that only that part of the Moon which is in the sunlight and which is also inside of the line of its orbit can be seen from the Earth.

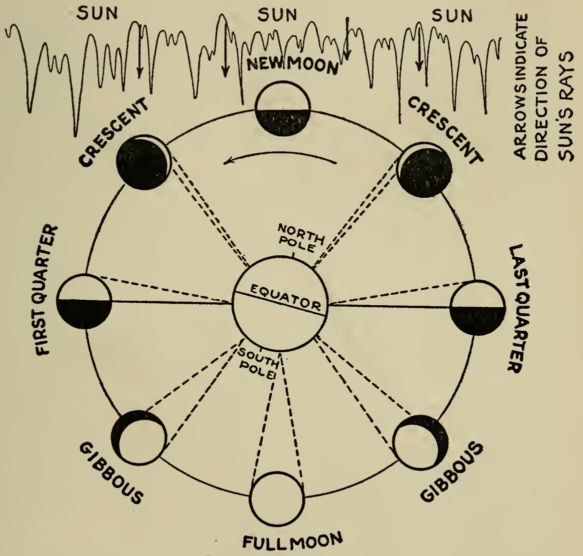


FIG. 110.—DIAGRAM OF THE MOON'S PHASES AS WE SEE THEM.

Starting now with the new Moon, Fig. 109, it will be seen that the Moon is directly between the Earth and the Sun and hence that part of the Moon toward the Earth is in the shadow. Now, since the eye can see nothing in the sky which is not shining, and since the Moon rises and sets at the same time as the Sun, we cannot see it. As the Moon moves on round the

Earth in the direction of the arrow and while half of it is in the light and half of it is in the shadow as before, from our position we are now able to see a narrow strip of its bright surface which in Fig. 109 is shown as a wedge, but since we are looking at it from an angle we see it as a crescent, as shown in Fig. 110.

The Moon having reached its first quarter sets at midnight and from the Earth half of its bright surface can be seen, which of course is only one quarter of the Moon's whole surface. The next phase of the Moon is when nearly all of its bright side can be seen. This is the gibbous phase and the Moon then seems to be about the shape of a football.

After the gibbous phase the full moon appears and this takes place in that part of the sky opposite the setting Sun. When the Moon is full it shines all night and does not set until sunrise.

From this time on the bright part of the Moon which we can see grows less and the gibbous phase again takes place. Soon the Moon reaches its last quarter and gradually the straight rough edge is hollowed out and another crescent is formed. The Moon is now in the east and the horns of the crescent point to the west, just opposite to the direction the horns of the new Moon pointed. The horns of the new and old crescents always point away from the Sun and this also is a good thing to remember.

To show how the Moon changes its phases perform the following simple experiment: Peel half an orange and push a knitting needle through its center and let this be the Moon. Your eyes will serve for the Earth and a lighted lamp will make a very good Sun, all of which is shown in Fig. 111.

Hold the orange by the knitting needle well out from your body with the peeled side toward you, and in such a position that the orange will be between your eyes and the lamp. The side of the orange toward you will be in the shadow and this represents the new Moon.

Now slowly turn your body round to the left and always

hold the orange with the peeled side toward you. You will see that the light from the lamp striking the orange forms a crescent with its horns pointing away from the light.

Keep on turning, a little at a time, and soon a quarter of the orange will reflect the light and this is like the first quarter of the Moon. When you have turned nearly halfway round nearly half of the orange will shine by the reflected light of the lamp and you will have a fair example of the gibbous Moon.

When you have turned your back to the light hold the orange above your head so that your shadow will not hide it; now half of the orange —the half that is peeled— reflects the lamp-light and represents the Moon when it is full.

As you keep turning round the amount of light reflected by the orange, which you can see grows less and less, the bright part at first being gibbous, then the last quarter is seen, after that a thin crescent, and finally when you have turned completely round the orange is again between your eyes and the light, hence it can no longer be seen, and the new Moon phase is again at hand.

Fig. 111.—Boy, Lamp and Orange Showing Phases of Moon.

The Harvest and Hunter's Moon.—You will remember that on September 21 the days and nights are equal and this is called the *Autumn Equinox*. The full moon that falls nearest to September 21 is called the *Harvest Moon* as it rises at nearly the same hour for several nights in succession and this makes the moonlight evenings unusually long. The *Hunters' Moon* follows the Harvest Moon.

How the Moon Makes the Tides.—When we are at the sea-

shore we soon see that there is a regular rise and fall of the ocean.

This rise and fall of the waters is called the *tide,* and if we note the time when the waters have reached the highest point—which is called *high tide*—we will find that a little over six hours later the waters have reached their lowest point—or *low tide.*

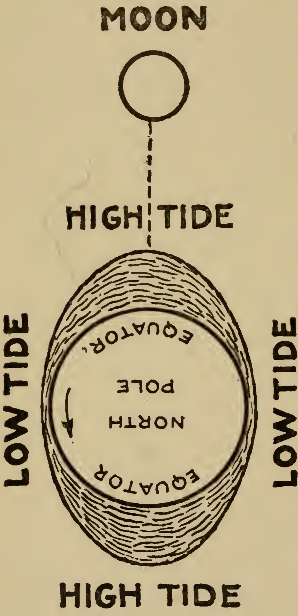


Fig. 112.—Attraction of the Moon Causes the Tides.

Before the tide has reached the high point again another six hours and some minutes have passed so that from one high tide to another high tide 12 hours and 25 minutes have elapsed. These tides are chiefly caused by two forces acting on the oceans, one being the attraction of the Moon for the Earth, and the other being the centrifugal force set up by the Earth's motion round its axis.

The effect of the Moon's attraction for the Earth is to pull the water of the ocean on the side of the Earth nearest it, and this forms a bulge, or great wave, while on the other side of the Earth the centrifugal force acts stronger on the water than the attraction of the Moon, and this pulls the water in the opposite direction. Thus two tidal waves are formed at the same time, one on each side of the Earth, as shown in Fig. 112.

Since the Earth revolves round its axis once in 24 hours these tidal waves are carried with it and as there are two tidal

waves each day there are two high tides and two low tides at every place on the ocean, but these are chiefly noticeable on the coasts. Fig. 112 shows the position of the Moon and the Earth, while the wavy lines around the Earth represent the oceans.

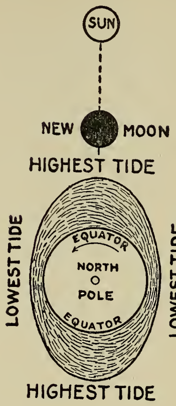


FIG. 113.—HOW SPRING TIDES ARE FORMED.

Spring Tides and Neap Tides. — Not only does the Moon's attraction cause the tides, but the Sun's pull on the Earth also produces tides.

When the Sun and Moon are in a line with the Earth they pull together and the tides are raised very high and they fall very low, and these high and low tides are called *spring tides.*

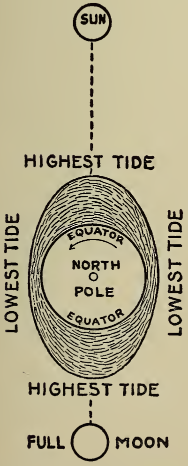


FIG. 114.—HOW SPRING TIDES ARE FORMED.

Since we have either new Moon or full Moon, when the Sun, Earth and Moon are in a line, the spring tides occur at these times, or twice every month. Figs. 113 and 114 show how the spring tides are formed.

When the Moon is at its first quarter, as in Fig. 115, or in its last quarter, as in Fig. 116, the Sun's pull and the Moon's pull oppose each other and the tides are lowest. These low tides, which take place twice a month, are called *Neap tides.*

A Trip to the Moon.—Many stories have been told about imaginary trips to the Moon and what the adventurers saw after reaching their destination.

Our story is made up of facts and the only thing we shall imagine is that

we have made the trip and set foot somewhere on the Moon. Having performed this mental somersault we shall carefully leave out all the hard questions about living there without air and water, for this is a pleasure trip and we don't want to spoil the fun with details.

On landing after our 240,000-mile trip we find that there is not only neither air nor water, but that the Moon is stone cold; even when the Sun shines on it, it is freezing cold, while the

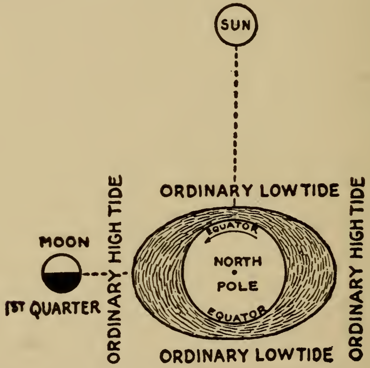


Fig. 115.—How Neap Tides Are Formed.

temperature drops to 500 degrees below zero when the Moon's night comes on.

Our next observation will probably be that we feel much lighter than we did on Earth and we are lighter in the very nature of things, for the weight of bodies on the Moon is only one-sixth as much as they are on the Earth. This is due to the Moon being so small and light that gravity has only one-sixth as great an attractive force there as it has on the Earth.

Supposing we still retained on the Moon as much strength as we had on the Earth; then every time we took a step we would cover a distance of 15 or 20 feet; if we jumped we would sail through space with the agility of a Harlem goat, and if

we played ball and batted the sphere fairly it would shoot off a quarter of a mile and go twice as far from the home plate.

Since there is no air on the Moon, in order to see one another the Sun would have to shine directly on us, and if by any chance we should get into a shadow we would be as completely lost to view as if we had fallen into one of the craters, for a shadow on the Moon is as deep and black as the darkest

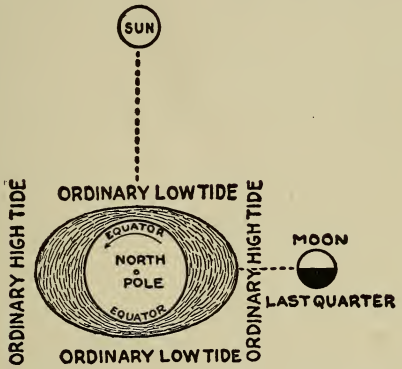


FIG. 116.—HOW NEAP TIDES ARE FORMED.

night you ever saw on Earth. Shadows as we know them on the Earth are always softened, for the air scatters the light.

Nor would it do us any good to cry out or whistle, for, since sound waves are carried by the air, and since there is no air on the Moon, all our efforts to make ourselves heard would be useless, even if we were only a few feet from each other. The Moon is just as silent and cold and still as it looks, for, though it serves the Earth well as a mirror to reflect the Sun's light, it is, after all, only a great, burned-out cinder.

Looking at the sky at night from the Moon, we are surprised to find how much bigger and brighter the stars seem, and how many more of them can be seen, than from the Earth.

Here we see as many with the naked eye as we could see from the Earth with a three-inch telescope.

The Earth itself is seen like a mighty Moon—a Moon as bright as 13 of the Moons we are calling on, and so large is it that we can see, not only the continents and oceans, but the

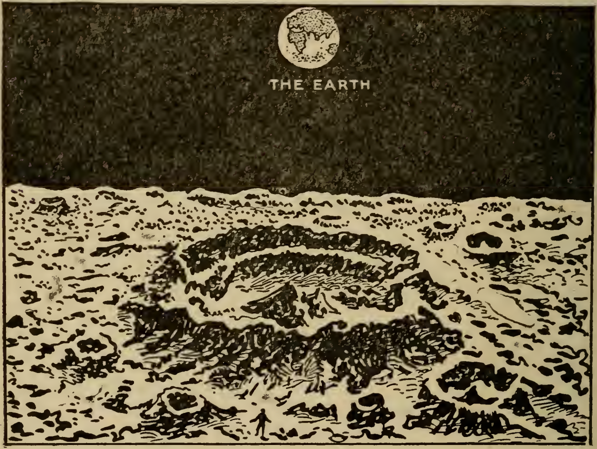


FIG. 117.—VIEW OF THE EARTH FROM THE MOON.

polar ice caps and the plains and the mountains as well, as shown in Fig. 117.

Watching the Earth from this new viewpoint, we see it turn on its axis every 24 hours and going through all the phases—crescent, quarter, gibbous and full, and back to crescent again, just as the Moon does when we see it from the Earth.

More curious than the Earth is the view we get of the Sun from the Moon, the lack of air making the seeing so good that the spots on the Sun, the fiery prominences and the thin corona can all be easily seen with the naked eye.

When the Moon is new the whole half of the Earth that is

turned toward the Moon is sunlit and by its reflected light we can easily read our time-card—for we must get back to Earth again and either write a book or lecture about the wonders we have seen.

The Moon and the Weather.—We have seen in Chapter III that our weather is entirely dependent on the Sun. Still it is believed by many persons to-day that the Moon has also some-

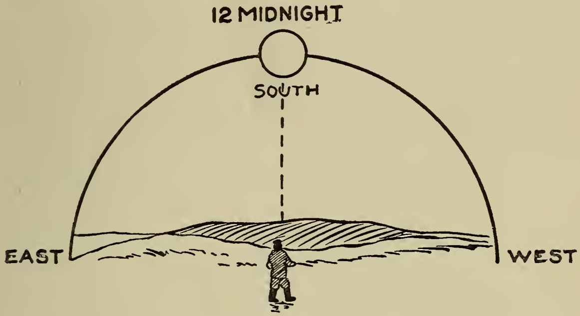


FIG. 118.—TELLING TIME BY THE MOON.

thing to do with the changes in the weather, just as it is the cause of the tides.

Hence there have been handed down to us a large number of old sayings to show what the weather will be during certain phases of the Moon. But it has been proved by records kept of the weather that the Moon has nothing whatever to do with it. For this reason no reliance is to be placed in any forecast of the weather which is founded on changes of the Moon.

How to Tell Time by the Moon.—After having learned how to tell the hour of the day by the Sun you should learn to tell the hour of the night by the Moon.

On some nights this is a very simple thing to do, for when the Moon is full it is due south at exactly 12 o'clock midnight, as shown in Fig. 118.

Every night before the Moon is full you will find it due south 55 minutes earlier, so that you must subtract 55 minutes from 12 o'clock for each day; that is, one day before full Moon it is due south at 11:05 P. M.; two days before full Moon it is due south at 10:10 P. M.; three days before full Moon it is due south at 9:15 P. M., and so on.

After the Moon is full it will be due south 55 minutes later every night and then you must add 55 minutes to 12 o'clock; that is, one day after full Moon it is due south at 12:55 A. M.; two days after full Moon it is due south at 1:50 A. M.; three days after full Moon it is due south at 2:45 A. M., and so on.

The Moon's day is 27½ of our days long.

The Moon's year is 27½ of our days long.

The Moon's diameter is 2,160 miles.

The distance from the Moon to the Earth is 240,000 miles.

CHAPTER VII

OTHER THINGS IN THE SKY

Seeing an Eclipse.—The word *eclipse* is taken from the Greek and means to fail to appear.

In starcraft, when the Earth passes across the Sun, and the Moon is hidden in its shadow, we say that it is an eclipse of the Moon; or when the Moon passes across the Sun and covers it we say that there has been an eclipse of the Sun.

How eclipses of the Sun and of the Moon are caused can be shown by a very simple experiment and you ought to make it.

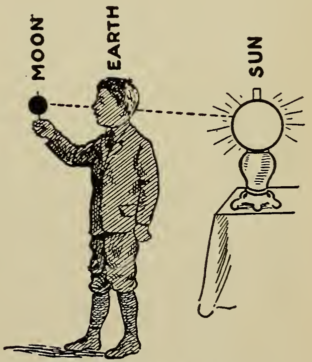


FIG. 119.—ECLIPSE OF THE MOON BY THE EARTH (EXPERIMENT).

An Eclipse of the Moon.—First let us suppose it is the Moon which is eclipsed by the Earth. All that is needed to show how this is done is a lighted lamp on a table and an apple with a knitting needle through its center. Let the flame of the lamp represent the Sun, your head the Earth and the apple the Moon.

Hold the apple by the knitting needle in a line between your eyes and the flame and turn round just as you did in the experiment showing the phases of the Moon. When you have turned halfway round the apple will be in the shadow of your head, when the apple is eclipsed, as shown in Fig. 119.

This is just what happens when the Earth gets between the Sun and the Moon and all these bodies are in a straight line,

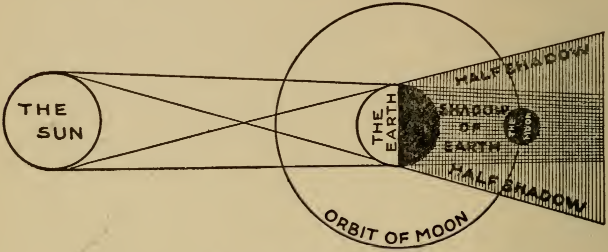


Fig. 120.—Moon Eclipsed by the Earth (Diagram).

as shown in Fig. 120; the Moon will then be in the shadow of the Earth, and thus it is that the Moon is eclipsed.

If the Sun, Earth and Moon were always in a straight line with each other, every time the Earth passed between the Sun and the Moon the latter would be plunged into the Earth's shadow and the Moon would be eclipsed. But the Moon does not revolve round the Earth so that it and the Earth make a straight line with the Sun every revolution for the reason that the Moon's orbit is tilted a little and hence it is only once in a while that all of these bodies get in a straight line with each other, and when these times do happen then eclipses are produced.

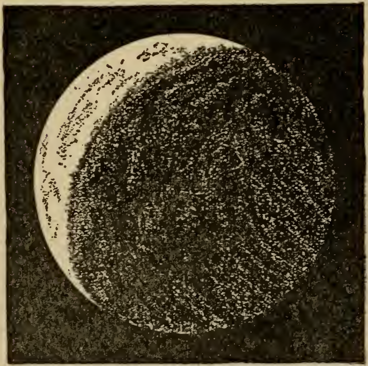


Fig. 121.—The Moon as Seen When in Eclipse.

Again when the Moon is eclipsed it is not always entirely hidden from view by the great shadow of the Earth, for the air on the Earth sends the sunbeams round it so that the shadow is never very deep, and for this reason the Moon can still be seen, as shown in Fig. 121. So, then, some of these bent sunbeams fall on the Moon and are reflected from its surface back to us and it is then that we see the Moon in an entirely new light.

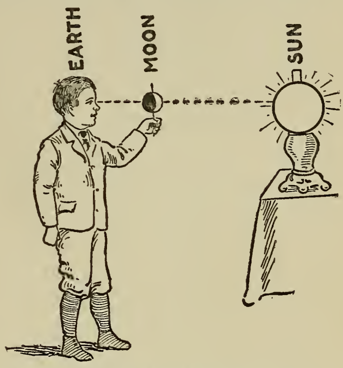


FIG. 122.—ECLIPSE OF THE SUN BY THE MOON (EXPERIMENT).

Sometimes during an eclipse of the Moon the man can still be seen, but instead of having a bright silvery face he will have changed it to the copper color of a red Indian. The whole eclipse of the Moon often lasts longer than three hours and the time the moon is in the deep shadow of the Earth is nearly two hours.

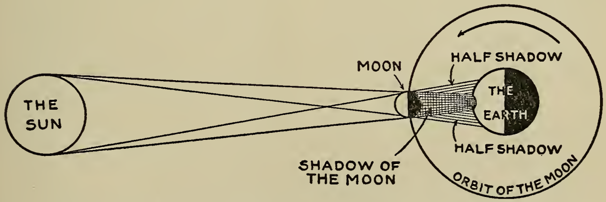


FIG. 123.—THE SUN ECLIPSED BY THE MOON (DIAGRAM).

A *total eclipse* is one in which the Moon passes completely into the shadow of the Earth, while a *partial eclipse* is one where only part of the Moon is in the shadow of the Earth and

part of it is in the sunlight. Eclipses of the Moon occur quite often and you can look up the time of the next one in your almanac.

Eclipse of the Sun.—When the Sun is eclipsed it is caused by the Moon passing between the Earth and the Sun and so the light is cut off from the latter.

To show how this is done all that is needed is to continue the experiment with the lighted lamp and the apple which you used for the eclipse of the Moon. You will remember in that experiment you were turned with your back to the lamp and with the apple held in front of you.

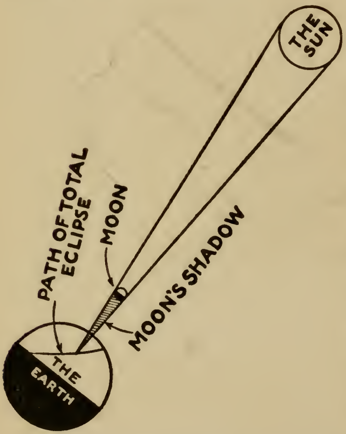


Fig. 124.—Total Eclipse of the Sun, Showing Path of the Sun.

Now to show how the Sun is eclipsed by the Moon keep on turning round until you face the lighted lamp with the apple in between and in a straight line with your eyes and the flame, as shown in Fig. 122.

Again you will find that the side of the apple nearest you will be in a deep shadow, though usually it can still be seen, and though you can see the light all round the apple yet you cannot see the flame.

This is exactly what takes place when the Moon gets between the Earth and the Sun and all of these bodies are in a straight line, as shown in Fig. 123; the Moon will then cover up the Sun and the shadow of the Moon will fall upon the Earth in a circle about 100 miles in diameter, as shown in Fig. 124. It is thus that the Sun is eclipsed.

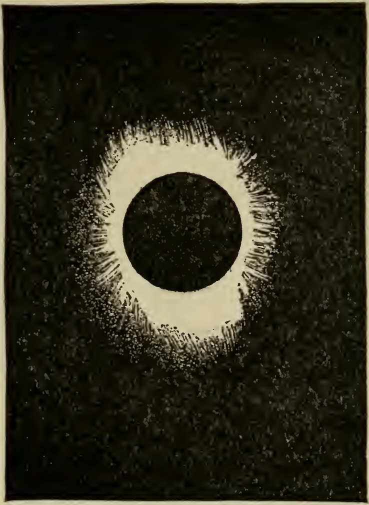


FIG. 125.—TOTAL ECLIPSE OF THE SUN, FROM PHOTO.

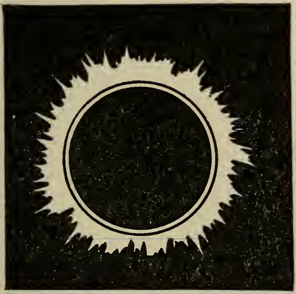


FIG. 126.—ANNULAR ECLIPSE OF THE SUN.

FIG. 127.—PARTIAL ECLIPSE OF THE SUN.

As the Moon is traveling round the Earth and the Earth is turning round on its own axis, the Moon's shadow moves across a path or trail that is only about 100 miles wide, and it moves very fast, too, for it usually takes less than five minutes for the Moon to sweep over the face of the Sun.

There are three kinds of eclipses of the Sun. The first is called a *total eclipse,* and this takes place when the Moon covers the entire face of the Sun, as in Fig. 125.

The second is called an *annular eclipse* and this takes place when the Moon does not completely cover the Sun but leaves a bright ring exposed, as shown in Fig. 126. The reason the Moon covers the Sun completely during a total eclipse and does not cover all of it during an annular eclipse is because the orbit of the Moon around the Earth is not a perfect circle, and so sometimes the Moon is nearer the Earth than at other times and this makes the Moon seem larger or smaller, as the case may be.

The third kind is called a *partial eclipse.* If we are not in the direct path of the shadow of the Moon we may see the Moon pass over only a part of the Sun, as shown in Fig. 127.

The only total eclipses of the Sun which can be seen in the United States in the next 30 years are the following:

Date of Eclipse	Time of Total Phase	Course of Moon's Shadow
1918, June 18,	2 minutes	Oregon to Florida
1922, Sept. 2,	6 minutes	Pacific Ocean, U. S. & West Indies
1923, Sept. 10,	3 minutes	U. S. & Atlantic Ocean
1930, April 28,	2 seconds	U. S. & Canada
1945, July 9,	1 minute	U. S., Canada, Scandinavia and Russia

Note: The eclipse of 1930 will be an annular eclipse.

Finding a Comet.—To the naked eye a great *comet* looks like a bright star with a long, glowing tail. In the long ago a comet was called a hairy star, for the early Greeks pictured the tail of a comet as being made of long hair and so from their language we get the word comet, which means hair.

A comet is really made up of three parts, which are, (1) a bright head or core, called a *nucleus,* and this is covered with (2) a layer of hazy light, called a *coma,* to which there is at-

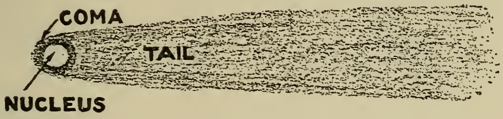


Fig. 128.—Comet Showing Nucleus, Coma and Tail.

tached (3) a luminous *tail,* all of which is shown in Fig. 128. The nucleus of a comet is formed of a bunch of stones and pieces of iron, all widely separated and which are held together by attraction as they speed through space. As a comet nears the Sun it begins to get hot and to throw off burning gases, which make up its coma, and these bright gases streaming along form its tail.

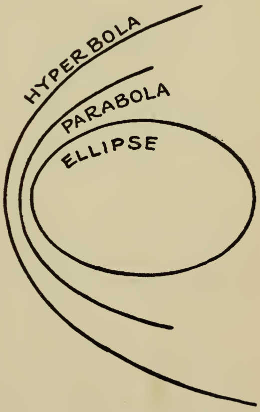


Fig. 129.—An Ellipse, Parabola and Hyperbola.

There are several ways in which a comet can be told from the planets. In the first place, new comets, that is, comets which have never been discovered before, appear suddenly and in any part of the sky, though they may be very dim at first, and after a while they fade away, sometimes never to return again.

Second, they shine chiefly with their own light like the stars; third, they do not travel in small circles around the Sun like the planets; but the paths they take are either long ovals, called *ellipses,* or great curves whose ends never meet, called *parabolas* and *hyperbolas,* as shown in Fig. 129; fourth, they do not travel through space in a line with

the planets and Sun, but shoot in and out of our solar system from and to every direction; and fifth and last, they travel at enormously high speeds.

Now, a comet, however great it may grow to be, never bursts into view, big, bright and beautiful, but when one is found it is usually seen as a little, dim patch of light, and it would quite

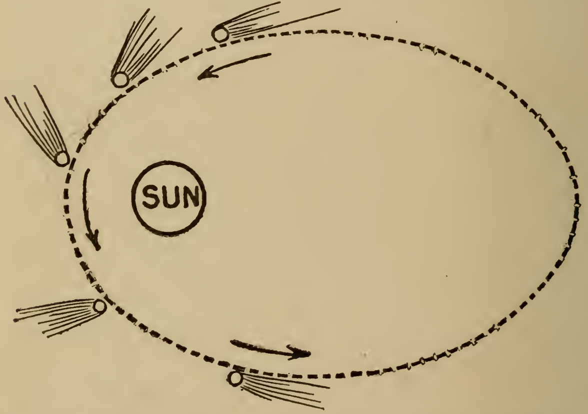


FIG. 130.—HEAD AND TAIL OF COMET DO NOT OBEY THE SAME LAWS.

likely be mistaken for a *nebula,* if it did not move along so swiftly.

A comet can be told by its movement and its movement can be plotted in the same way I have described for plotting the position of a planet in Chapter IV; and so, if you see a dim, little ball of light in the sky and find that it changes its position when compared with the fixed stars near it you may guess that you have discovered a comet.

The next thing you should make sure of is, that you have not found one of our old familiar friends, the planets. If it is really a great comet coming toward the Sun, it will grow larger and brighter every night, and you will soon be able

to see its tail, which is the real earmark of a really truly comet.

When a comet is nearest us its head will shine far brighter than any of the planets, and its great tail, millions of miles in length, will spread out in a glowing arc and light up the whole sky.

When this time comes a comet is by far a greater sight to the naked eye than it is when seen through the largest telescope.

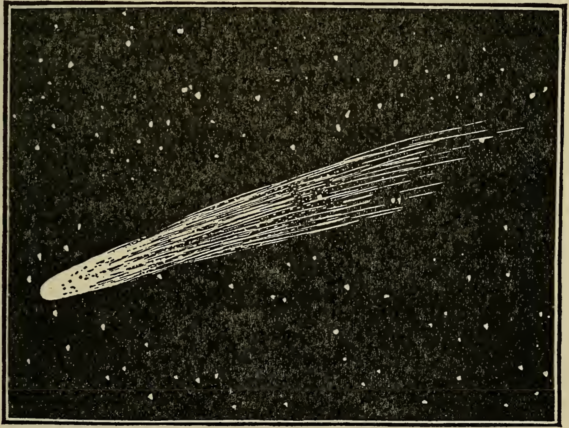


FIG. 131.—HALLEY'S COMET, FROM PHOTO.

You should observe the comet often and carefully, for another one may not appear for a long time.

The nearer a comet gets to the Sun the faster it travels; some comets have been known to move a thousand times as fast as a rifle-ball, and this is the more surprising when we consider that the great, flaming tail goes along with it at the same terrific rate of speed.

The tails of comets do some very strange things; for example we should rather expect the tail of a comet to always follow

its head like a skyrocket, but while it does so when the comet is headed toward the Sun, when the comet is passing round and shooting into space the tail turns away from the Sun, and this causes it to move ahead of the comet, as shown in Fig. 130.

This shows that while the head of a comet obeys the laws of gravitation, the tail does not do so, but acts as if it was electrified like the Sun, when of course it would be repelled by it. Fig. 131 is a picture of Halley's comet of 1910.

Although a great astronomer once said that there are more comets in the sky than fishes in the sea, there have only been 1,000 comets recorded since the beginning of written history.

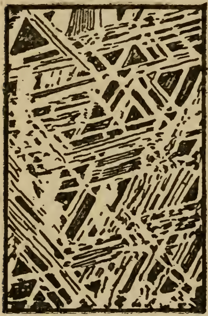


Fig. 132.—Meteorite of Iron Etched with Acid.

Meteors and Meteorites.—If you will look at almost any part of the sky on a clear night when there is no Moon you will no doubt see a bright flash like a rocket. But if you will scan the sky during the dark nights of August and November you will be very apt to see dozens of these shooting stars or meteors.

Now, *meteors, fireballs, shooting stars* and *meteorites* are all one and the same thing to start with and they have their beginnings when some comet goes to pieces.

After a comet breaks up, the pieces of stone and iron which form it still travel round in the same orbit. Some of these pieces may get within range of the Earth's force of gravitation when they are drawn to it, and on striking the air they are intensely heated by the friction, and if they are small they burn up before reaching the ground.

The smaller meteors burn up almost instantly and the shining tails they leave last only a few seconds. Fireballs, which are simply large meteors, leave burning trails which can sometimes be seen for several minutes. Shooting stars are merely

meteors which are not very bright, while meteorites are meteors which have fallen to the Earth before they have had time to burn up.

Many meteorites have been found, but ninety-five out of every hundred are of the stony kind, the others being of the iron kind. The way to tell a meteorite from a common stone is by examining its surface. A true meteorite is covered with a black, shiny, burnt crust, caused by the intense heat to which it was subjected as it fell through the air. The test for an iron

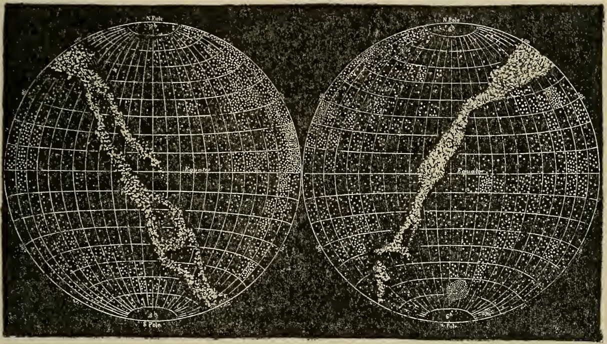


Fig. 133.—The Milky Way.

meteorite is to grind and polish a part of its surface and then cover it with a dilute solution of nitric acid, when markings like those shown in Fig. 132 will be etched upon it.

The Milky Way.—You have, no doubt, often seen on a clear, dark night, a wide, ragged band of light stretching from the northern sky across the celestial equator and beyond. This band of light is the famous Milky Way.

If, as you were looking at the Milky Way, the Earth could be moved from under you and you were left standing in space alone so that you could see in every direction, you would find that the band formed a complete ring round the sky.

To the naked eye the Milky Way seems to be made up of mists of matter as thin as the stuff of which comets' tails are made. There are some patches, though, that are very bright, but look at them as long as you will with the naked eye nothing more can be seen than just a milky patch of hazy white, as shown in Fig. 133.

With a very small telescope, however, this band of luminous matter will be instantly changed into thousands of stars, all separate and distinct, and some of these stars will look about as large as the stars of the Pleiades when these are seen with the naked eye, while others will shine as brightly as Venus or Jupiter when they are nearest to the Earth.

These bright patches, then, which form the Milky Way, are really groups of stars or star-clusters, and when some of these clusters are photographed through a telescope as many as 15 or 20 thousand stars can be counted, while the real number of stars that lie beyond and which cannot be seen is past all calculation, and, just think of it, every one of these stars is a Sun as large or larger than our Sun!

Those who have made a deep study of starcraft tell us that our Sun is one of the stars of the Milky Way, and since the other fixed star that is nearest to us, which is *Alpha Centaurus,* is 25 trillion miles away, and Sirius, the Dog Star, which is the brightest star in the whole sky, is three times as far away as Alpha Centaurus, we may gain some slight idea of the enormous distances of the fainter stars that make up the Milky Way.

The Nebulæ.—Unlike the bright, cloud-like patches in the Milky Way, and which the telescope shows to be formed of separate and distinct stars, are the faint misty spots in the sky called *nebulæ* (or nebule).

Now the nebulæ give us a clew as to how the stars were made, and how other stars are now being made, for it is believed that the nebulæ are the raw material which, when set in motion, produced heat and took on form and became Suns and planets like our own solar system.

Two ideas of what these nebulæ are made of have been worked

out. The first concludes that they are formed of hot gases and particles of other matter; and the second takes them to be small solid bodies all very far apart and moving round tiny orbits like a lot of little planets.

There are a few of these nebulæ which can be seen with the naked eye; one of these is the *Great Nebula of Orion,* and if you will look at Orion some night and draw an imaginary line a little below his belt and toward the east you will be able to find it. Another nebula that is bright enough to be seen with the naked eye is the *Great Nebula in Andromeda.* Both of

FIG. 134.—DIFFERENT FORMS OF NEBULÆ.

these nebulæ are good tests for eyesight. Fig. 134 shows some of the different forms of nebulæ.

The Making of the Stars.—To explain how our Sun and the planets were made, as well as all the other stars in the universe, two ideas have been worked out, and although these are quite unlike in many ways, yet both start out with the nebulæ. The first of these is called the *nebular hypothesis* and the other and later one is called the *planetesimal hypothesis.*

The Nebular Hypothesis.—We have found out what *nebula* is believed to be and we should next understand exactly what the word *hypothesis* means. An hypothesis is an idea worked out so that there is a fairly good chance of its being true.

The *nebular hypothesis,* then, is an idea that has been worked out from what nebulæ are believed to be and what is known of the mighty forces of nature, and these when taken together

seem to show that all the things in the sky—stars, planets, moons, comets and meteors—are made of nebular stuff.

The neublar hypothesis says that when the nebular matter, or star stuff of which the planets were made, was thrown off into space by the centrifugal force of the Sun, they were all whirled away in the same plane, turning on their own axes and traveling round the Sun in the same direction.

The Planetesimal Hypothesis.—A later idea is called the *planetesimal hypothesis*. *Planetesimal* means little planet, and as we know already what hypothesis means, by coupling the two words together we may easily guess that it is an idea worked out which accounts for the making of solar systems out of little planets.

The planetesimal hypothesis also starts with a great nebula, but instead of taking the nebula to be made of hot gases and like particles of matter, it says that the nebula is already formed of meteors which travel in orbits of their own and hence are really little planets.

The meteors, or little planets, making up the nebula, attract each other, like all other bodies, and when they get close enough they are drawn together and dense masses of matter, or cores, are built up. The largest core is seen in the center of a spiral nebula, and as it becomes more compact it grows hotter and a Sun is made, while the other and smaller cores turn round it and attract little planets to them. And so the cores grow in size, and with more and more weight bearing toward their centers the gases are forced out and these make the air and water.

It is in this manner that the planetesimal hypothesis explains how the Sun, planets and Moons of the solar system are made.

CHAPTER VIII

SEEING THE STARS

How the Stars Shine.—A burning match, a candle, an oil or gas flame, the Sun, comets and meteors all give out light and heat in exactly the same way, though they may seem to do so quite differently.

When you strike a match the friction makes enough heat to light the chemicals of which the head is formed and the burning gases light the splint which in turn generates more gases from the wood and these give out more light and heat.

When you light a candle the heat melts the wax which is then drawn up the wick, the burning gas around the wick produces more gas and the gas keeps the flame going. In the case of an oil lamp the oil, which is already a fluid, is drawn up by the wick, where it is changed into gases, and light and heat result as in the candle. The oil lamp is, then, a step ahead of the candle, for the solid wax is replaced by the fluid oil.

In the gas light the gas, which is made of coal or other matter, is forced out of the jet under pressure and this gives a bigger and better flame than the oil lamp; and, as the oil lamp is better than the candle, so the gas jet is an improvement over the oil lamp.

Now the Sun is so large and the burning gases are so hot that when solid matters, such as iron and other metals, are thrown out by the great eruptions from the inside they are not only melted but they are instantly changed into gases and the burning gases send out both light and heat.

When a comet comes close enough to the Earth to be seen it is then close enough to the Sun so that the light and heat of the Sun cause some of the gases of which the nucleus of the comet

is formed, to become white hot; as a comet gets closer to the Sun the solid matter of the nucleus, such as sodium—which is a kind of salt—iron and other things are changed into gases and these burn fiercely.

While we can see the light of a comet we cannot feel its heat, for a comet is too small to send its heat waves through such a great distance.

Just as a match is lit by striking it, so meteors are set on fire by striking the air. Meteors are made up of the same kind of matter as cómets and when these shooting stars come within the attraction of the Earth the friction caused by the meteor rubbing against the air is so great that an intense heat is produced and the gases burst into flame.

If a meteor is small it is entirely burned up before it reaches the Earth and all we see of it is a bright streak of light. If a meteor is large enough only the outside of it is burned and it will, in consequence, reach the Earth, when it becomes, as explained in the last chapter, a meteorite.

Meteors and meteorites produce a very bright light, burning as they do in the oxygen of our air, and though they are very close to us they are so small we cannot feel any heat sent out by them.

We have said that when a match is struck the friction produces heat and that when the wax of a candle, the oil of a lamp or the gas of a jet is burned they produce light and heat, and this is also true of the blazing Sun, the fiery comets and the burning meteors.

Where there is light there is usually heat and turn about where there is heat there is light if the temperature is high enough. Heat is produced before light, but the two are nearly always found together and they are so much alike they might be called the Siamese twins.

What Heat and Light Are.—We know that both heat and light are caused by burning gases, but let's get a little closer and find out just how and why gases which are burning send out heat and light.

Now gases are formed of particles of matter called *atoms* and these atoms are very small but they have a certain size and weight according to the substance they form. When these gases are cold the particles, or atoms, are quiet, but when they are heated to a high temperature they are thrown into a violent state of motion and *vibrate* to and fro a given number of times per second, or *frequency,* as it is called, according to the substances they are made of.

The next question in order is what makes the particles, or atoms move, or vibrate and the answer is *combustion,* which means the process of burning. Combustion, or burning is a chemical action and can be explained by saying that it is the combining of a substance with oxygen, but many substances like hydrogen will burn if they are heated without being combined with oxygen.

The only difference between heat and light is that of *wave length* as we shall see presently, and the length of heat waves and of light waves depends entirely on the rapidity with which the atoms vibrate, or the *frequency of vibration,* as it is called. If the atoms of gas move slowly heat is sent out and if the atoms move rapidly the heat grows more intense and light is radiated.

When the atoms of a burning gas vibrate just fast enough to produce light the color of the light is red; when the atoms vibrate still faster the color of the light is green and when the atoms vibrate very fast the light sent out is violet, so we see that not only do the vibrating atoms send out light but that the rapidity, or frequency with which they vibrate makes, or determines, the color as well of the light which is sent out.

One thing more: the rapidity of the motion, or vibration, of the atoms of a gas depends entirely on the substance which is being burned, so that certain substances when burning always produce certain colors. (See Chapter XII, *What the Stars Are Made Of.*)

How Heat and Light Travel.—While the little motions or vibrations, of the particles, or atoms, of gas forming the flame of

a candle, the Sun, and other heat and light givers could go on just the same we could not feel their heat or see their light without something or some kind of a substance which would connect them with our bodies and our eyes, like a wire connecting a push button with an electric bell. And there *is* something which connects us with the most distant stars and that something is called the *ether.*

FIG. 135.—RIPPLES OR WAVES ON WATER.

To show how these little movements, or vibrations set up by the atoms of a flame impress us as heat or light do at a distance we will begin with a simple experiment to show what the ether is and how it acts.

If you will stand on the edge of a pool of water and throw a stone into the middle of it you will see a little ring-like ripple, or wave start out from the point where the stone struck the water; this ripple, or water wave will continue to grow larger and larger in diameter and weaker and weaker until it reaches the edge of the pond, as shown in Fig. 135, or if the pond is very large the waves will die out before they reach the edge.

Again, if you toss a number of stones into the middle of the pond one after another a series of ring-like waves will

follow from the center of the pond where the stones strike the water to the edge of the pond, or until they die out.

In the same manner if a bell is struck by a blow of its tongue, ripples, or waves in the air will be sent out all around the bell. These waves in the air are called *sound waves,* but they are, after all, only *air waves.*

When a bell is struck the rim of the bell moves forth and back, first in one direction and then in the other, as shown in the diagram, Fig. 136, and we call these little movements of the bell *vibrations.* The movements are so small that you cannot see them, but if you put your finger on the bell you can feel them.

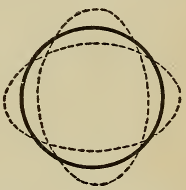


FIG. 136.—VIBRATION OF A BELL.

Although the vibrations of a bell are very small they are powerful enough to set up ripples, or waves in the air as shown in Fig. 137, and when these air waves or sound waves strike the drum of the ear it vibrates just like the bell and the *auditory nerve* of the ear carries the waves on to the brain and we hear the bell ring.

It must be plain now that if there was no air connecting the bell with our ears the bell might keep on ringing and yet we could not hear it.

When the air is set in motion by the vibrations of a bell, or any other device for producing from 32 to 40,000 vibrations per second, we can hear it, and when the air moves as a mass, as when the wind blows, we can feel it. Air forms a layer around the Earth that is between 200 and 300 miles thick, but out in the great space beyond there is no air. Yet the space is not empty, but it is filled instead with a substance called the ether.

Just as the air is finer than water so the ether is a million times finer than the air. It is so fine that it fills up all the little spaces between the particles or atoms of water and of the air, and it penetrates in between the atoms of the densest metals and the hardest glass, and further, and still more wonderful, it

fills all of the great space in which the planets and the stars are placed.

Now when the particles, or atoms of gas are set in motion, or vibration by a flame of any kind, be it a candle or the Sun, little ripples or waves are started in the ether and if these waves are very short they affect the eye and cause the *optic nerve* to vibrate exactly like the vibrations which are sending out the ether waves and these waves are carried to our brains

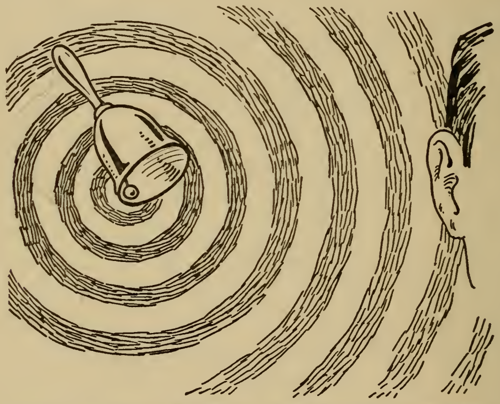


Fig. 137.—Sound Waves in the Air Set up by Bell.

and we *see* the light. The way in which a flame sends out waves in the ether and is received by the eye, is shown in Fig. 138.

It takes a ripple, or wave on the water started by the impact of a stone about one-half second to travel one foot. A sound wave, set up by the vibrations of a bell, or other sound producing device, travels through the air at the rate of 1,090 feet per second, while light and heat waves set up by the vibrations of a flame, the Sun or other hot body, travel through the ether at the rate of 186,500 miles per second.

It must be plain now that if there was no ether connecting

the flame, or the Sun with our eyes the flame, or Sun might continue to send out light and yet we could not see it.

How the Eye Sees.—If it was not for our ears we could not hear a bell ring nor any sound, for though the waves in the air might still be sent out we would have no means of receiving them; again if it was not for our eyes we could not see a flame, the Sun or any other source of light and, what would be worse, we could not see an object by its reflected light, for though

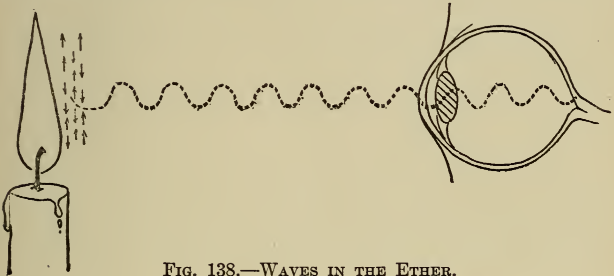


FIG. 138.—WAVES IN THE ETHER.

the waves in the ether would still be sent out we would have no means of receiving them.

The eye is simply a camera on a very small scale, but what it lacks in size it makes up by the excellence of its operation. If you will set up a sheet of white cardboard on one end of your starboard, place a lighted candle at the other end and then hold your burning glass between the flame of the candle and the cardboard, as shown in Fig. 139, and do all this in an otherwise dark room, you will see a picture turned upside down, called an *inverted image,* of the candle flame on the cardboard.

To get a sharp picture, or image of the flame on the cardboard screen you will have to move the lens toward and away from the cardboard, and this process is called focusing. If you will fix the lens in the front of a light-tight box and place a sheet of ground glass in the back of the box you will have a simple, though crude, camera.

The eye has all of the things which the highest priced camera has and a good deal more, for all of its adjustments are automatically made, and you don't even have to think about them.

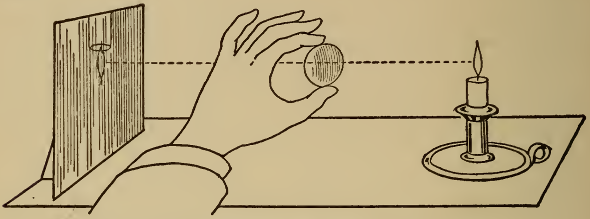


Fig. 139.—Forming an Image with a Lens.

The eye is almost as round as a ball and it can be turned a little in its bony socket in any direction. The outer part of an eye which takes the place of the box of a camera, is stretched round the whole eye like the cover of a baseball, as shown in

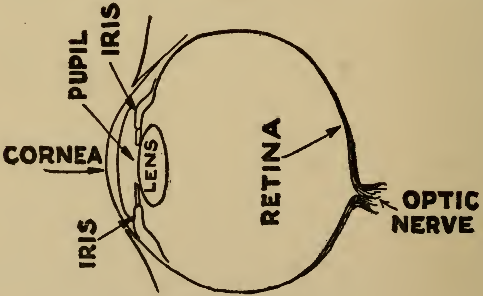


Fig. 140.—The Human Eye.

Fig. 140. The front part of this cover forms the white of the eye, and fitting into the cover and over the lens, like a watch crystal in its rim, is the *cornea,* which is a tough, but transparent film and protects the *iris* and the *lens.*

Between the lens and the cornea is a thin disk, or diaphram with a hole in its center and this is the iris; the purpose of the iris is to let in only a certain amount of light, just like the shutter of a good camera. The hole in the iris forms the *pupil* of the eye, and you can see the hole, or pupil, grow larger or smaller, just as the eye needs more or less light.

The lining of the eye is called the *retina* and this forms a screen at the back of the eye on which the light waves in the ether project the image of the object at which the eye is looking. Instead of being white like our cardboard screen the retina is very black.

The retina upon which the image is formed is connected with the optic nerve; in fact, the retina is a part of the optic nerve and is covered with a lot of little nerve ends or filaments called *rods* and *cones*.

Now when the waves in the ether sent out by the flame of a candle, or by the Sun, reach the eye, they pass through the cornea, then through the pupil, or hole in the iris, and finally through the lens which focuses the waves on the retina and forms the image there.

The different colors of light are caused by waves in the ether of different lengths; when very short waves strike the retina we say the color is violet; waves a little longer we call green and the longest waves which the eye can see form in our brains the sensation of red.

Waves in the ether which are longer than the wave lengths the eye can see produce heat and when these waves fall on any part of the body the nerves detect them and we call the sensation heat. On the other hand waves in the ether which are too short to affect the nerves of the eye will impress a photographic plate.

The iris of the eye acts as a self-regulating shutter, which makes the hole, or pupil in front of the lens larger or smaller according to the amount of light which is needed to see an object well. If the light is strong the iris contracts, which means that the hole gets smaller and so cuts off some of the light. If the

light is weak the hole gets larger and we say the pupil expands and this lets more light through the lens.

There must also be some means of adjustment to make a sharp image, or picture, on the retina, however near or far away the object may be from the eye. In a camera this is done by moving the lens and the screen closer together or farther apart and this is the purpose of the bellows of a camera.

But the eye has a much finer and quicker adjustment than this for distance. The lens is so made that the front part of it can bend just as the distance changes. You have only to look at an object and the lens is adjusted without the slightest effort or knowledge on your part.

You may wonder how light waves can pass through a substance as solid and as hard as glass or through the eye. You will remember I told you in the beginning of this chapter how ether got into every little space, even in metals and glass, as well as that it filled all the great space between the stars.

We think of glass as being very solid, and it is solid enough to keep water or air in a bottle from getting out through its pores. But glass and the substance of which the eye is made are just about as full of holes as a sieve, but the holes are so very, very small you couldn't begin to see them even with the aid of a high-power miscroscope, yet they are large enough for the ether to run through just as water runs through a sieve.

When I tell you that waves in the ether which are sent out by the light of a candle or the Sun are only about 15 ten-millionths to 30 ten-millionths of an inch in length, and that the holes, or pores, in the glass and the cornea and lens of the eye, and which are full of ether, are much larger, you can readily understand that the ether waves which we call light can merrily pass through either glass or the eye and that there is nothing in the way to stop them.

To sum up briefly how the stars shine, how light travels and how the eye sees we will start with the light of the Sun and say

(1) That the Sun is made up largely of gases, and that

(2) These gases are formed of various substances, and that

(3) The gases are burning fiercely and produce terrific heat, which means that

(4) The atoms or particles which form the gases are in violent motion or vibration.

(5) These vibrations start out waves in the ether which travel out into space at a speed of about 186,500 miles per second.

(6) On reaching the eye the waves pass through the lens and form a picture or image

(7) On the retina, or screen of the eye, which is made up of the ends of nerves, and these vibrate just as the atoms of the gases in the Sun which sent out the waves vibrated, and finally

(8) These nerve vibrations are sent over the optic nerve to the brain, where they take on the shape, size and colors of the Sun.

Reflection of Light.—The flame of a match, or a candle, an oil or a gas lamp, or Sun, comet or meteor, produces its own light, and for this reason these bodies are called *self-luminous* —that is, they are themselves the source of light.

All other objects which do not produce light, such as an apple, a stone, the Earth and other planets and moons are called *non-luminous bodies.*

Yet these non-luminous bodies can send out light if they are lighted up by some self-luminous body. It is well that this is so, or else we could never see anything that was not in itself giving out light.

If you will hold an apple or a stone in your hand and let the light of a candle or the Sun fall on it you will be able to see the apple or stone, and, although you will hardly be able to notice it, you will see them by the light which strikes them and is turned back, or *reflected* from their surfaces, as shown in Fig. 141.

If a rubber ball is thrown on the sidewalk it will bounce back and this is just the way light acts when it strikes most

objects—it bounces back, or, to use the right word, it is reflected.

When we look at the surface of the Earth by daylight we see the sand and stones, grass and trees, houses and other objects by the light which is reflected, or thrown back from the surface of these things by the Sun.

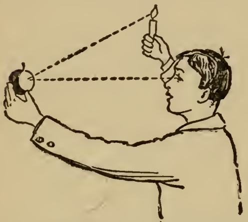


Fig. 141.—Light Reflected by an Apple.

When we look at the surface of the Earth by the light of the Moon we also see the objects by reflected light, but in this case the light is twice reflected, for moonlight is the light of the Sun falling on the Moon and which is then reflected to the Earth, where it is again reflected to our eyes from the objects it falls on. This is the reason moonlight is so pale when compared with sunlight.

Refraction of Light.—When a beam of light passes through glass, water and other transparent substances, and is bent out of a straight line it is said to be *refracted.*

Place a spoon in a glass of water, as shown in Fig. 142 and it will look as if the spoon is broken in two at the point where it touches the water. The bending of the beam of light will be more clearly understood from the drawing in Fig. 143.

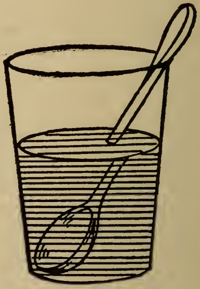


Fig. 142.—Light Refracted. Spoon in Glass of Water.

If you will look at a star through a thick piece of glass and the star seems to change its position a little you will know that the sides of the glass are not quite parallel.

A *prism* is a three-sided piece of glass, if we except the ends, as shown in Fig. 144. When a beam of light passes

through a prism the prism affects the light in two ways: first, it bends the beam, and second, it separates the ether waves, or light waves, as they are called, according to their lengths, and as color depends on the length of the waves in the ether a

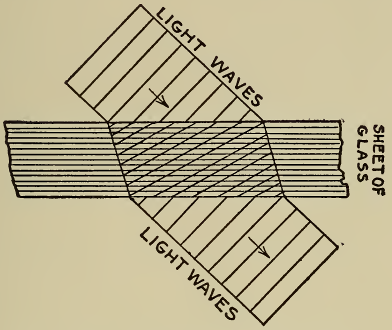


FIG. 143.—HOW LIGHT IS REFRACTED.

prism will show the different colors on a screen and this is called the *spectrum*. It is shown in Fig. 145.

Lenses are pieces of glass having curved surfaces. When a beam of light passes through a lens it is also bent out of its original direction, or refracted.

A *convex lens,* see Fig. 146, is a lens which is thicker in the middle than it is at the edges. A convex lens is used for magnifying an object; or for forming an image so that it can be magnified by another lens as in a telescope, for forming an image on the screen of a camera, and for bringing the heat waves of the Sun to a focus, as with a burning glass.

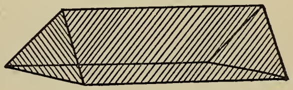


FIG. 144.—PRISM.

The point where the rays of light are brought together is called the *focus*. You can easily find the focus of a lens by

holding a sheet of paper, or the hand under the lens and letting the sunlight pass through it; where the spot of light is smallest

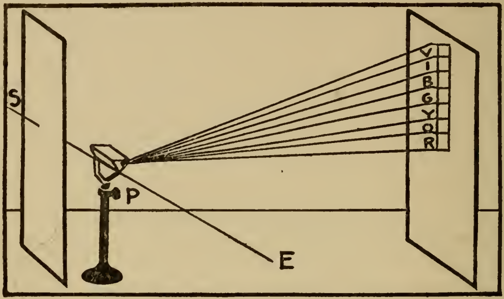


FIG. 145.—PRISM FORMING A SPECTRUM.

and brightest the distance of this point from the lens is called the *focal length.*

A *concave lens* is a lens which is thinner at the middle than

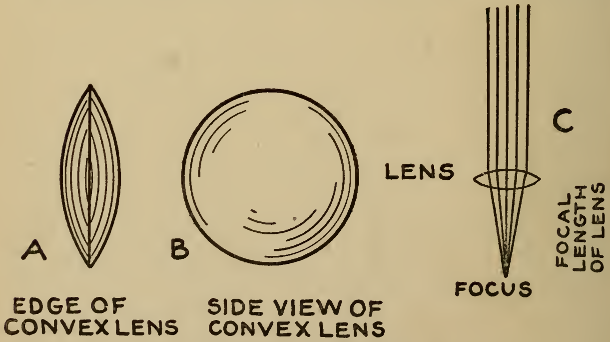


FIG. 146.—CONVEX LENS.

it is at the edge, as shown in Fig. 147. It is used in small telescopes and opera glasses to turn the inverted picture formed

by the convex lens around so that the object can be seen in its right position, as shown in Fig. 151.

Shadows.—*Shadows* are useful as well as sunshine, but shadows are such common, everyday things it seems almost useless to talk about them; still you may or may not know that there are different kinds of shadows.

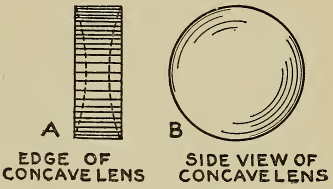


Fig. 147.—Concave Lens.

Of course we all know that when a candle or a gas-light or the Sun shines on an apple or any other *opaque* object—that is, an object that will not let the ether waves go through it—the light is cut off back of it and this dark space is called a shadow; this is also true when the Sun shines on the Earth, or on any of the other planets or their moons.

There are always two parts to the shadow of an object unless the light is a mere point or the object is very close to the screen, or surface on which the shadow falls. The dark part of the shadow is called the *umbra*. The edge of the object where the light and shade run together and form a partial shadow is called the *penumbra* and during a total eclipse this partial shadow surrounds the dark shadow, or umbra of the Earth or Moon.

CHAPTER IX

THE SPYGLASS OR TELESCOPE

The Boy Who Discovered the Telescope.—Spectacles have been made and used for nearly a thousand years and the art of making lenses is very much older.

A little over three hundred years ago there lived in Amsterdam, Holland, a spectacle maker named Lipperhey, and it is said of him that he made good lenses.

There was apprenticed to this lens grinder a Dutch boy, and I am sorry I cannot tell you his name, for he was a boy who did things; but his name is not recorded, which is a shame, for if it had not been for this boy Galileo might never have had a telescope.

One day while the boss was out this Dutch boy was standing before a window of the shop and he held a lens before his eye with one hand and another lens before the first lens with his other hand, as shown in Fig. 148. Imagine his surprise when the church he was looking at seemed to move much nearer to him, that is to say, the image of the church was greatly enlarged.

The boy had made a wonderful discovery—he had discovered the *telescope.* When his master returned the boy showed him what he had done and it was not long before the great Galileo had a telescope and was startling the world by his wonderful discoveries of the moons of Jupiter, the rings of Saturn, the phases of Venus, the spots on the Sun and a hundred other wonders of the sky.

A telescope is an arrangement of lenses in a tube for making the image of a distant object larger on the retina of the

eye, or, as in the case of the fixed stars, for making them brighter.

The word telescope comes from two Greek words, the first, *tele,* which means afar, and the second, *scope,* which means to

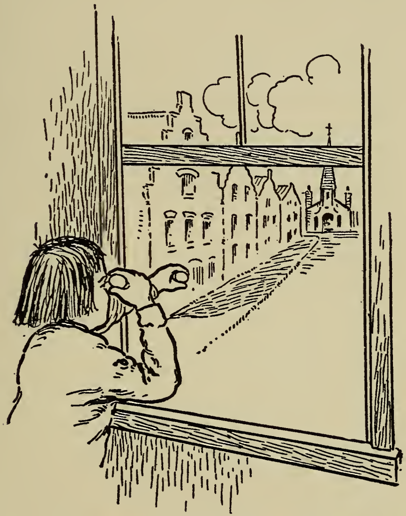


FIG. 148.—LIPPERHEY'S BOY DISCOVERS THE TELESCOPE.

see, so that telescope means just what we should expect it to mean and that is to see afar.

There are several kinds of telescopes, but there are only two kinds I want to make clear to you here; in the first kind the eye sees the object just as it is, that is, standing right side up, or *erect.* This kind of a telescope is called a *spyglass,* and is used to look at objects on the surface of the Earth.

In the second kind of telescope the eye sees the object upside down, or *inverted,* and this kind of telescope, which is

called an *astronomical telescope,* is just as good as the other for looking at the stars.

A Pinhole Telescope.—Before describing how to make and use real telescopes which have lenses I want to tell you of a little scheme to see afar, and though it does not magnify the image of the object that is seen through it, yet it aids the naked eye when you are looking at the Sun and Stars.

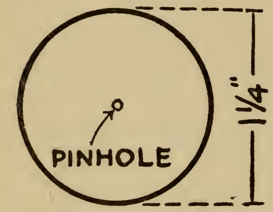


FIG. 149.—DISK OF CARDBOARD FOR PINHOLE TELESCOPE.

To make a pinhole telescope get a pasteboard tube about 1¼ inches in diameter and 5 or 6 inches long. A paper tube for mailing papers and sheet music is just the thing and can be bought at any stationery store.

Cut out a *disk,* or circular piece of cardboard just large enough to fit the tube, see Fig. 149, and push a pin point or needle through the center to make a small, clean hole. Next, glue this cardboard disk in the tube ½ an inch from one end.

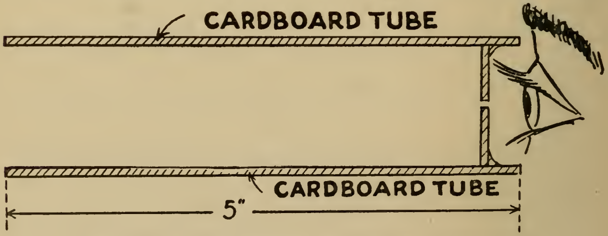


FIG. 150.—CROSS SECTION OF PINHOLE TELESCOPE.

The disk must be glued in the tube so that no light can leak around the edge.

If, now, you look at the Sun through the pinhole telescope, as shown in Fig. 150, you will get a better view of it than if you look at it through a pinhole in the cardboard alone,

for the tube shuts out all the other rays of light from the eye.

To improve the seeing qualities of the pinhole telescope make the hole in the cardboard disk ¼ inch in diameter and cover this hole with a bit of tinfoil. Now make a hole in the center of the tinfoil with the point of a needle; this makes the edge of the hole sharp.

A pasteboard tube without the pinhole will also aid the naked eye in seeing the Moon and stars, for it shuts out all the rays of light around the eye and limits the sight to a certain part of the sky; together these things are very good helps in observing especially if there are gas and electric lights nearby.

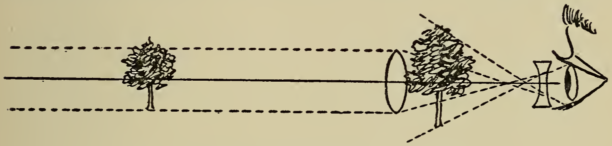


Fig. 151.—The Telescope (Galileo).

How a Telescope Works.—A real telescope has at least two lenses in it; the larger lens is placed in the end of the tube nearest the object to be viewed and is called the *object glass* because the light from the object is received by it.

The smaller lens is placed in the end of the tube nearest the eye, and is called the *eyepiece*, for it is this lens which enlarges, or magnifies the image of the object that is thrown upon the retina of the eye.

There are two simple kinds of telescopes; the first is the kind that Galileo used for making his great discoveries. The kind of lenses used and the way they are placed in the tube is shown in Fig. 151.

In this telescope the object glass is a double convex lens and the beam of light which strikes it is brought to a point as in the case of a burning glass, but before the light reaches this point it is caught up by the double concave lens which forms

the eyepiece, when it is carried to the eye in an erect position.

An opera glass is simply a pair of these little telescopes, joined together so that they can be focused at the same time by means of an adjusting screw, as shown in Fig. 152.

Another simple telescope is formed of two double convex lenses. As in the telescope just described the larger lens, or object glass, is placed in the end of the tube nearest the object to be viewed and the smaller lens, or eyepiece, is placed in the tube nearest the eye.

Fig. 152.—Opera Glasses.

In this telescope, though, the eyepiece is a double convex lens and while a larger image is formed in the eye it is inverted, or upside down, so that this kind of a telescope is of no use as a glass to spy things with on the surface of the Earth.

How to Make a Cheap Telescope.—Lenses are absurdly cheap. If you live in a large city you will find lens grinders who will sell you the kind of lenses you need for either kind of telescope for a dollar or so.

Telescope No. 1.—This telescope is fashioned after an opera glass, that is, it has a concave lens for an eyepiece.

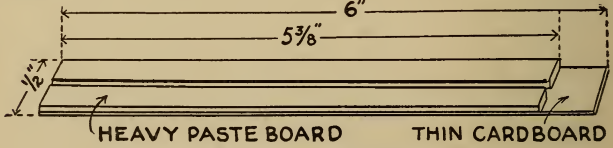


Fig. 153.—Pasteboard Mounting of Lens.

Get two pasteboard tubes of the kind described for the pinhole telescope; the bore, or hole, of the first tube should be 1¾ inches in diameter and it should be 2 inches long. Have the second tube a little smaller than 1¾ inches in diameter on the outside so that it will slide easily into the larger tube and yet not leak light, and have this tube 1½ inches long.

Paint the inside of both tubes with black paint to keep the walls of the tube from reflecting any stray rays of light which may strike them. The outside of both tubes can be covered with bookbinders' cloth to give them a neat appearance.

The next step is to mount the lenses. The larger lens for the object glass is a double convex lens 1½ inches in diameter and having a 12-inch focal length, or *focus,* as it is called for short. A lens of this kind can be bought for 25 or 30 cents. The smaller lens for the eyepiece is a double concave lens 1 inch in diameter and having a focus of 6 inches. This lens can be had for about 40 cents.

FIG. 154. — PASTEBOARD LENS MOUNTING.

Cut a strip of thin, tough cardboard ½ inch wide and 6 inches long; on this strip glue a strip of heavy pasteboard ½ inch wide and 5⅜ inches long, and have one end of both pieces even, as shown in Fig. 153. Set a flatiron on the pieces and let them dry. When dry make a groove down the middle of the

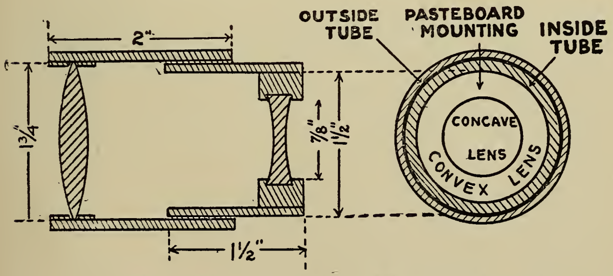


FIG. 155.—OPERA GLASS TELESCOPE. CROSS SECTION.

heavy pasteboard by slicing out a very thin strip with the point of a sharp knife, being careful not to cut through the thin cardboard. Now bend the strips around the lens with the lens in the groove, glue over the thin end as shown in Fig. 154, and slip

a rubber band or tie a string around it to hold it in position until it has dried.

The small concave lens, or eyepiece, is mounted in the same way, but since the lens is only 1 inch in diameter, cut the strip of cardboard ½ inch wide and 4¼ inches long and the strip of thick pasteboard ½ inch wide and 3½ inches long; this done glue them together, cut the groove and mount the lens as before.

The next and last thing is to smear glue on the cardboard mounts and push the convex lens in the end of the large tube and the concave lens in the end of the small tube. Now slide

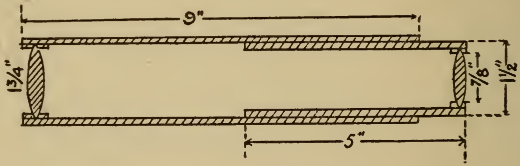


Fig. 156.—Telescope. Cross Section View.

the tubes together and you will have as good a telescope as the boy who invented it. It is shown in cross section in Fig. 155.

You should, however, make two caps, one for each end of the telescope to cover the lenses when not in use. This little telescope is very handy to carry along on your scouting trips, as it takes up so little room, being only 2 inches long when closed up.

Telescope No. 2.—This telescope is very much better than the one just described for seeing the stars as it magnifies about 4 times.

It is made exactly like the first one except that the larger tube is 9 inches long and the smaller tube is 5 inches long. In this telescope both lenses are double convex, the large one, or object glass, having a diameter of 1½ inches and a focal length of 12 inches, while the smaller lens, or eyepiece, has a diameter of 1 inch and a focal length of 3 inches. It is shown in cross

section in Fig. 156. A spyglass usually has four or five *plano-convex lenses* in it and these not only magnify the image but they also erect it so that you see the object as it really is.

While the homemade telescopes which I have described will not magnify as highly as a cheap telescope which you can buy, yet you ought to make one, for it will let you into the secret of combining lenses, and this is as interesting as seeing the stars. By all means make your first telescope and then if you want a better one buy it and get one as large as you can afford.

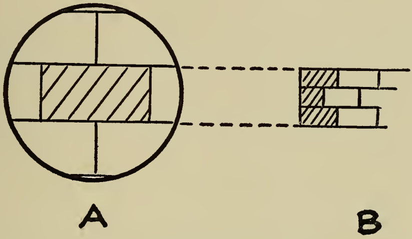


FIG. 157.—MAGNIFYING POWER OF TELESCOPE.

To Find the Power of a Telescope.—In the last chapter, I explained what the *focal length* of a convex lens is, see Fig. 146, and how to measure it. To repeat, it is the distance in inches between the center of a lens and the point where the rays come together.

You can find exactly what the *magnifying power* of your telescope is, when both lenses are convex, by dividing the focal length of the object glass by the focal length of the eyepiece, or lens.

For instance, suppose the focal length of the convex object glass of your telescope is 12 inches and the focal length of the convex eye lens is 3 inches, then 3/12 and the quotient 4 is the
4
magnifying power in times or *diameters* of your telescope.

To find the focal length of a concave lens is a little harder,

but Garrett P. Serviss tells us in his good little book on *Astronomy with an Opera Glass* of an easy way to judge the magnifying power of an opera glass and it is just the same for a telescope. Look at a brick wall through one of the tubes with one eye while the other naked eye sees the wall direct.

Now notice how many bricks which the naked eye can see, are needed to equal the thickness of one brick as seen through the glass. The number of bricks seen with the naked eye represents the magnifying power of the glass. Fig. 157 shows how the bricks are compared.

The Stars Seen Through a Spyglass.—The Moon. —When Galileo lived the people believed that the Moon was a ball as smooth and bright as a glass marble and they also thought that the dark spots on its surface were the continents of our Earth reflected by it.

So the first thing Galileo did when he got his telescope was to turn it on the Moon, for he wanted to know about these dark spots, and you can imagine his surprise and delight to find that they were really great mountains and extinct volcanoes.

You cannot do better than to point your little homemade telescope at the Moon, stop, look and rediscover the mountains on it and be as surprised and delighted as Galileo was, three hundred years ago. To see the mountains at their best do not wait until the Moon is full, for the sunlight then shines directly on top of the mountains and there are no shadows to help the eye to gauge breadths and heights.

The best time to see the mountains is when the Moon is in its first or its last quarter, for then they are well brought out by the bright sunlight shining on them from the side and the black shadows which they cast on the other side.

The great smooth stretches seen on the Moon are called seas. It may be that in the long ago they were really seas, but it is more likely that Galileo and the early observers whose telescopes were little better than yours thought they were seas. Then there are huge cracks or gorges on the surface of the Moon, which start from some of the craters and run for hundreds of

miles in every direction. A number of these gorges start from a volcano named *Tycho* (pronounced Ti′-co) and make the Moon look as if it is cracked; and it is likely that when the Moon cooled down from its melted state after having been shot off from the Earth it did crack in many places. Fig. 158, which is

FIG. 158.—FULL VIEW OF MOON.

a good telescopic view of the Moon, shows some of these great cracks radiating from Tycho.

To show on a small scale how the Moon cracked on cooling down Nysmith filled a glass globe with cold water and then sealing the globe he plunged it into hot water. The slow expansion of the cold water by the hot water caused the globe to crack as shown in Fig. 159, and by comparing the pictures it will be seen that the cracks on the Moon and in the glass globe are very much alike.

There is a mountain called Aristarchus[1] (pronounced Ar-is-tar′-cus) which is believed to be formed of pure metal because it shines brighter than any other mountain on the Moon. Its position is shown on the map, Fig. 160.

The instant you look through your glass at the Moon the man which shows so plainly to the naked eye vanishes like a

Fig. 159.—Glass Globe Cracked.

coin in a magician's fingers and instead you will see a new world covered with plains and mountains.

But if you will look at the Moon when it is nine or more days old, you will see with the aid of your glass and a little imagination the Moon girl, as shown in Fig. 161. You should have no trouble in finding her, for the *Apennines* form her

[1] Aristarchus was a Greek who lived 200 years before Christ. He taught that the earth was round.

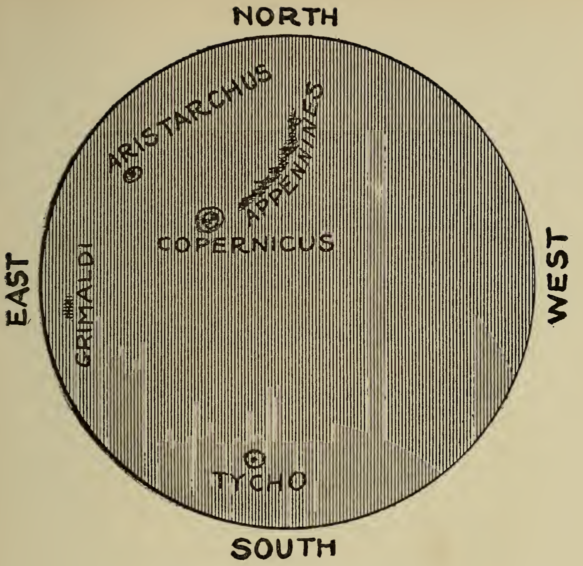


Fig. 160.—Map of the Moon.

Fig. 161.—The Moon Girl.

crown while Tycho shines upon her breast like a great yellow diamond.

There is another crater mountain which you should by all means know and that is Copernicus[1] (pronounced Ko-per′-ni-kus). Look through your glass at the southeastern end of the Apennines and you will see a crater that is larger in diameter than Tycho, though it is not so deep. Tycho, Copernicus and the Apennines will serve you well as landmarks if you follow up the explorations of the Moon which you have so well begun.

The Sun.—You can see the spots on the Sun quite well with your glass, and sunspots are always interesting.

Do not try to look at the Sun through your glass without covering the eyepiece either with a thickly smoked or dark-colored glass. You must also use smoked or colored glasses over your eyepiece when you are looking at an eclipse of the Sun.

This year, 1915, is one of the best years to see sunspots, for more can now be seen than at any other time since 1904, or which can again be seen until 1926.

The Planets.—After you have seen the mountains on the Moon and the spots on the Sun you should next turn your glass on the planets.

While you will probably say that the planets loom up very small—the largest, Jupiter, appearing about the size of the head of a large pin—yet they are wonderful to look at even through the smallest telescope.

Mercury.—This is a planet not easy to see even with the aid of a glass so if you see it you can think that you are lucky or skillful or perhaps a little of both.

Venus.—Venus can be seen very much better with your small glass than Mercury, but you will only be able to see it as a little disk and not as a crescent for your glass is of too low a magnify-

[1] Copernicus—Polish astronomer. Born 1473. Before his time it was believed that the Sun, Moon and stars revolved round the Earth. Copernicus showed that the Earth was a planet and, with the others, that it revolved round the Sun.

ing power. It is a brilliant object though even through the smallest glass.

Mars.—While you cannot see the canals of Mars with your glass you can see it as a bright disk of light and this is well worth while. Mars is believed to be peopled and the thought that it may be makes it a mighty interesting object to look at. Look at it through your glass and think it over.

Jupiter.—On account of his great size you will be able to see Jupiter better than any of the other planets. His disk will show clear and distinct and if you have good eyesight and your glass is fairly good you will be able to see one and perhaps two of his nine moons which will appear as little points of light close to the planet.

Saturn.—The rings of Saturn cannot be seen with a glass magnifying less than four times. His rings are at this writing (1915) in the best position to be seen as the flat side of the rings is toward us now. In 1921 the edge of his rings will be in a line with the Earth and then it will be very hard to see them even with a much larger telescope.

Uranus.—Although Uranus is so very far away, it can be seen with your glass, though you may not be able to see it as a disk of light.

You can tell when you have found Uranus by watching it for a few nights. If it changes its position among the stars around it you will know you are looking at Uranus.

Neptune.—Neptune is farther away than Uranus and your glass will show it as a mere point of light. Like Uranus you will know it if you see it, by its motion among the stars.

The Stars.—After you have looked at the Sun, Moon, and planets to your hearts' content turn your glass on the Big Dipper and you will see about ten times as many stars as you can see with the naked eye.

The Big Dipper is full of starry surprises as you will find to your pleasure on looking at it with your glass: for instance, instead of the handle being formed of three stars, it blazes with dozens of them.

Take a look at Alcor, which is the middle star in the handle of the Dipper. You may remember I told you in the first chapter that it had a little companion, Mizar, which only sharp eyes can see. Now look at Alcor through your glass and you will see that it and Mizar are quite widely separated.

The North Star is also a double star as these twin stars are called. Just as Mizar is a good test for the naked eye so the twin of the North Star is a good object on which you can try out the seeing power of your glass.

Another double star which some boys can separate with their keen naked eyes is *Epsilon,* named after one of the Greek letters (See Appendix C). This star together with Vega, a very bright and beautiful blue star of the first magnitude, and Zeta, another Greek letter star, form a *triangle,* which is the constellation of Lyra.

Whether or not you can separate Epsilon into two stars with the naked eye, you will see them stand out separate and distinct through your glass. If you had a more powerful glass you would see that each of the stars of Epsilon has a faint companion star, so that it is really a *quadruple star,* that is, there are four stars right together.

Then there is the Milky Way, always a wonderful sight to the naked eye, but still more wonderful when viewed through a glass however small; there are the stars of the Pleiades of which the eye sees not more than six or seven without help, but which bursts forth like a skyrocket into a cluster of many-colored lights when seen through a glass; these are only a few of the hundreds of other things which you can see in the sky with the help of your little telescope.

CHAPTER X

THE TIME O' DAY

What Time Is It?—This is a question everybody is always asking everybody else.

Did you ever stop to think what a curious thing *time* is? No one knows when it began nor can anyone tell when it will end, yet we measure off a little bit from that which has gone or from that which is yet to come, so that we may know when to eat, to start to work, or to quit, and when to go to bed or to get up.

We know that, roughly, a year is the time it takes the four seasons to come and go, and that this is done when the Earth travels once round the Sun; that the month is based on the time it takes the Moon to travel once round the Earth; that the week has nothing to do with the Sun, Earth, Moon or Stars, but is a pure invention, and, finally, that the day is the time it takes the Earth to turn once round on its axis.

But when we want to know what time it is we mean, of course, what the hour, the minute and, sometimes, even the second of the day is, and these are the small measured parts of time we want to find out about.

The time it takes the Earth to make one complete turn on its axis is divided naturally into two parts, more or less equal, depending on where we live, and these parts are daytime and nighttime.

This general division of time, marked by alternate daylight and darkness, may have served every need of the cave man at first, but just as he came to have sense enough to crawl into his cave to get out of the rain so the blazing Sun must finally

have driven into his awakening brain its use to him as a means of marking time.

As his savage mind grew less animal and more human, ideas were formed in it either by instinct or by the first vague glimmerings of reason and he began to think. He saw that when the light of the Sun fell on the trees and the rocks, long, strange, black marks, which we call shadows, were cast by them, and he must have noticed that the shadows swung round the trees and rocks in the opposite direction to the way the Sun was traveling.

To mark off with his eye and place a stone at a point somewhere near the middle of the shadow cast by the rising Sun and that cast by the setting Sun, and which would mean that the day was half done was the next great step.

These things were, quite likely, the first feeble efforts of the human race to measure time, and out of which the sundial came, as well as the crude beginnings on which the science of astronomy is based.

Solar Time, or Time by the Sun.—To make a sundial which would give correct Sun time was so hard a problem that men had to think about it for a million years before they could solve it and the chances are that then it was invented by a boy. You will find directions for making a simple sundial in Chapter III.

Now let's find out how we can know when a day begins and when it ends. On first thought this would seem to be an easy thing to do and it is if we are not particular about being exact. You will remember that a day is measured by the time it takes the Earth to turn once round on its axis and what we want to know, now, is how to tell when the Earth has made one complete turn, no more and no less.

We can tell this, you may say, by a clock or a watch, but the best of clocks and watches are always a little fast or a little slow, and time to-day is measured by the fraction of a second. So we get the *apparent time* from the Sun, change it into *mean time* and set our clocks and watches by it.

There are several ways by which we can obtain Sun time, but all of them are based on the same principle. The way that was used by people who first began to think about these things, and it is also a good way for you to try, is like this:

First you must have a good *horizon,* that is, you must be able

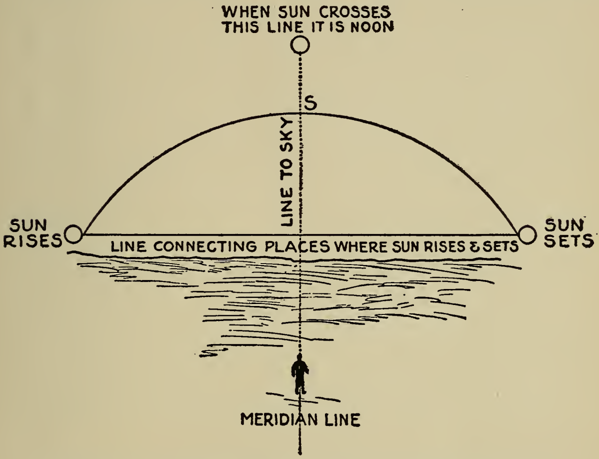


FIG. 162.—DIAGRAM SHOWING HOW TO FIND SOLAR NOON.

to see the Sun rise and set without any mountains or other things in the way.

When you begin your observations for getting solar time note exactly where the Sun rises and where it sets on the horizon. You can easily do this by using hills, houses and trees for marking the places. Now with your eye draw a line between these two points.

Notice also where you are standing and let your line of sight meet the imaginary line which joins the places where the Sun rises and sets just as near the middle as you can, and all of which is clearly shown in Fig. 162. Now this line will run

due north and south and hence it is a *meridian line* which you are to use to observe the Sun.

When the Sun reaches that point in the sky where it is directly over the middle of the imaginary line, joining the places where it rises and sets, it is exactly noon, *Sun time.*

The next day observe the Sun in the same way and when it crosses the meridian line again the Earth will have turned round once and you will have a part of time measured off called a Sun or *solar day.*

But when the time is taken between two succeeding crossings of a meridian by the Sun it is not true time and a day so measured is called by astronomers an *apparent solar day,* and when the Sun is on the meridian it is called *apparent noon.*

Now the word *apparent* means to seem, that is, something which seems to be true and yet is not true. An apparent solar day is then the length of a day measured by the Sun, and while we might suppose that the Sun at least would give the true length of a day this is not the case for the reason that the Earth does not travel in all parts of its orbit round the Sun at the same rate of speed, and, further, it is tilted on its axis; together these things make the days as measured off by the Sun unequal and hence they are called apparent solar days.

Mean Solar Time.—Apparent solar days which are of unequal length were all right as long as sundials were the only timepieces, but when clocks and watches came into use days which were equal in length were needed and needed badly, for a clock couldn't be made which would keep Sun time.

So astronomers who watched the stars by night lay awake during the day wondering how they could make the Earth travel round the Sun at the same speed every day in the year and just as though it was not tilted. At last they solved the problem.

And how do you think they did it? It was as easy as rolling off a log—when you know how. They simply *imagined* that the Earth traveled at a uniform speed and that it stood straight, as shown in Fig. 74. In other words they took the *mean length,* which is another way of saying the average length

of all the apparent solar days which make up a year, and divided it up equally. Further, the men who got up this scheme said that every day should have not only the same length, but that it should have 24 hours, and of course you know that hours are divided into minutes and minutes into seconds. *Mean solar time,* then, is really *imaginary Sun time* and this is the time used everywhere and watches and clocks are set by it.

Equation of Time.—To get the exact mean time each day you have to know just what the apparent solar time is, and then you have to know what the difference in time is between the apparent solar time and the mean time, that is how many minutes and seconds to add to or subtract from the solar time of each day to get the mean time.

This difference of time is called the *equation of time.* A table prepared by Professor Todd of the Amherst College Observatory is given in Appendix M and can be used for all ordinary purposes.

Standard Time.—A meridian, as you know, is an imaginary line running due north and south and hence we can have a meridian whenever we want it and as many as we like.

When the Sun crosses the meridian of those who are on it, it is noon to them, but to no one else, for the Sun has already crossed the meridian to the east of it and has yet to cross the one to the west of it.

As an illustration it takes the Sun about three hours to cross the United States from the Atlantic to the Pacific coasts. When the Sun crosses the meridian which passes through New York City it is noon here and it is likewise noon when the Sun crosses the meridians which pass through St. Louis, Denver and San Francisco, and this is true of every other place and of every other hour of the day. This is the reason why every place had its own, or *local time,* before the year of 1883.

Now as long as people traveled on foot, or by horse, they moved so slowly that local time did not worry them, but when railroads came into use there was all kinds of trouble for the traveler; if he was going west his watch was faster than the

local time of the towns he passed through and if he was going east his watch was always slower than the local time. If he wanted the right time he had to set his watch at every town he passed through; of course he couldn't very well do this and he was always in a stew.

The railroad companies were just as much put to for it was next to impossible to make a timetable to fit the local time of each town and still keep up a running schedule; and the result was that the railroads finally got up a system of their own which they called *railroad time.* This was all well enough for everybody but the poor traveler, who, not knowing the difference in time between local time and railroad time, nearly always found he was either an hour too early or—as it usually happened—a minute or two too late to catch his train.

As new towns sprung up and railroads multiplied, things had come to such a pretty pass in 1883 that nobody but the astronomers knew what the real time was, and they wouldn't tell; then a new time scheme was tried out, and as it is still used we must conclude it is a fairly good one. It is called the *zone,* or *belt system of standard time;* the time used is called standard time because the towns and cities and railroads all use it and there is no confusion.

To understand what *standard time* means we have to know first what a *standard meridian* is. A meridian, as we have said, is an imaginary line running due north and south anywhere we want it, but while a standard meridian is also a line running due north and south it has a fixed position.

The first fixed or *prime meridian,* as it is called, passes through *Greenwich* (pronounced Gren′-ij), which is a part of London, England. The reason this meridian was chosen by geographers to reckon distance east and west from is because the Royal Observatory at Greenwich is one of the oldest in the world and it was the first from which exact time was sent out.

If a circle is divided into 360 degrees, as shown in Fig. 163, and it is also divided into 24 parts, each part will be a space equal to 15 degrees or 1 hour. Now geographers have divided

the Earth into 24 equal parts by meridians separated by 15 degrees, and each space, or belt, between them represents 1 hour, as shown in Fig. 164. These fixed meridians start at the first, or prime meridian, at Greenwich and all the other meridians are measured in degrees east or west of Greenwich as the case may be.

FIG. 163.—CIRCLE DIVIDED INTO 360 DEGREES AND 24 HOURS.

Starting west from the first, or prime meridian, which passes through Greenwich the time at the second standard meridian, which is called the 15th meridian because it is 15 degrees from the first meridian, will be one hour behind Greenwich time.

At every standard meridian the mean solar time is used as the standard time and every place on it and halfway to the meridian or both sides uses it, and so local time and standard time are now one and the same thing.

This makes it very convenient for the traveler, for instead of setting his watch at each station he does not need to set it until he has traveled 15 degrees east or west, which is about 500 miles in our northern latitudes, and then he turns it exactly one hour ahead or one hour back, depending on the direction he is going.

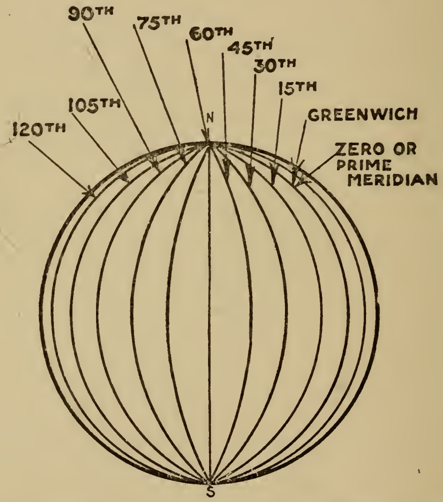


FIG. 164.—THE EARTH DIVIDED INTO 24 STANDARD MERIDIANS.

There are four standard time meridians running through the United States, as shown in the map in Fig. 165. The one running through New York, Pennsylvania, New Jersey and Delaware is the 75th meridian, meaning of course that it is 75 degrees west of the prime meridian which passes through Greenwich. Time on this meridian and halfway to the meridians on both sides of it is called *Eastern Time.* It is just five hours slower than Greenwich time.

The next is the 90th meridian and this one passes through

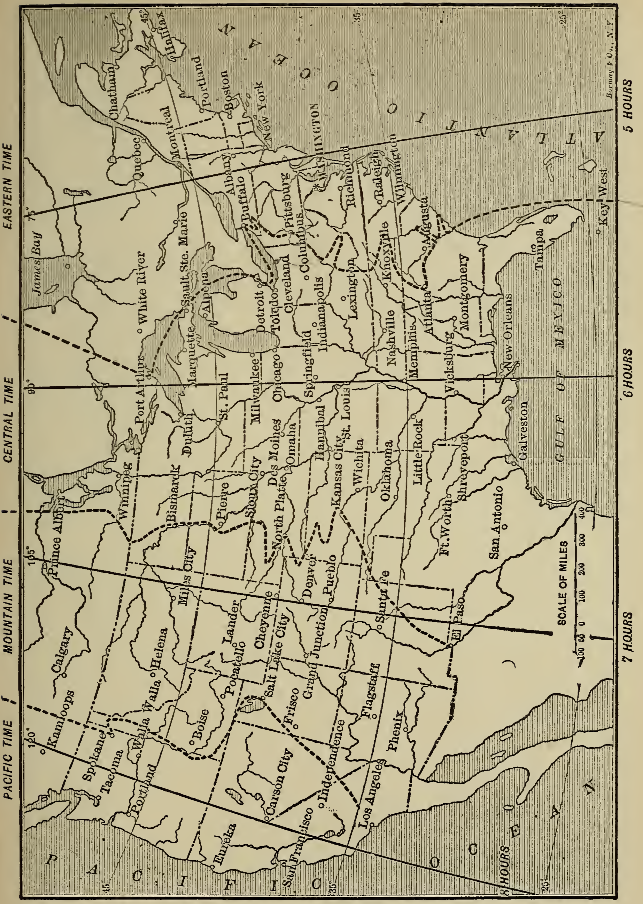


Fig. 165.—Standard Time Meridians in U. S.

Wisconsin, Illinois, Missouri, Tennessee, Mississippi and Louisiana. Time on and around this meridian is called *Central Time.*

The one after this is the 105th meridian and passes through Montana, Wyoming, Colorado, New Mexico and Texas. Time on and around this meridian is called *Mountain Time.* The last of the four meridians, the 120th, passes through the States of Washington, Oregon and California and time on and around this one is called *Pacific Time.* It is three hours slower than Eastern time and 8 hours slower than Greenwich time.

Although these meridians are just one hour apart the time is not changed on them nor exactly in the middle of a belt but at some well-known town or city between two of the meridians, as you will see by looking at the map, Fig. 165. Fig. 166 shows the standard time at different cities around the world north of the equator.

Star or Sidereal Time.—Besides all the different kinds of time described above there is still another and a very important kind of time, and this is obtained by the stars.

Just as Sun, or solar time is obtained by noting when the Sun crosses a meridian, so *star,* or *sidereal time* is obtained by observing when a star crosses a meridian. Now there is a difference between the length of a day when formed by the Sun crossing the meridian twice in succession and when formed by a star crossing the meridian twice in succession. This difference in time, between a solar day and a sidereal day, as they are called, is nearly four minutes.

But the point is this: an astronomer can obtain the time from watching a star cross the meridian much more accurately than he can from the Sun, because a star is a mere point of light, and it is easier for him to calculate the mean solar time from the *transit* of a star than it is for him to go to bed, and besides he would rather do it, too.

How Time Is Distributed.—In this country the correct standard time is sent out by the United States Naval Observatory at Washington to all cities east of the Rocky Mountains,

by *wire telegraph,* and all over the Atlantic ocean and seaboard by *wireless telegraph.*

When time is received over the wires from Washington it is distributed by local telegraph or by *time balls* to various jew-

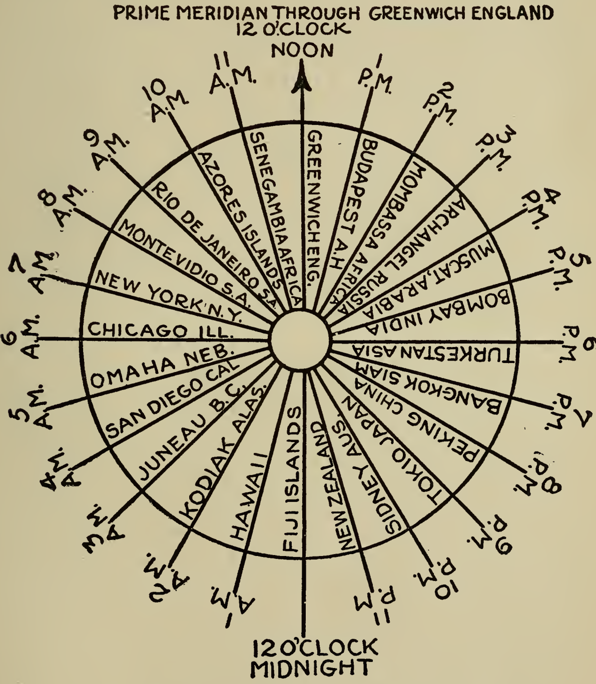


FIG. 166.—STANDARD TIME AT DIFFERENT CITIES.

elry stores and to private citizens who always want to be set right.

How an astronomer gets the correct time; how it is sent out over the wires and by wireless and how it is distributed to

the common people is a mighty interesting piece of business. Briefly it is like this:

How Correct Time Is Obtained.—Every observatory has, besides its big telescopes, a *transit instrument,* a wonderfully accurate *clock,* and a clockwork device called a *chronograph.* The transit instrument is nothing more than a telescope with a thin piece of clear glass with a number of lines ruled on it with a diamond, about 1/8 inch apart, and this ruled glass is set between the eyepiece and the object glass, as shown in Fig. 167.

This telescope, or transit instrument—so called because it is used to observe the *transit,* or passage, of a star across a merid-

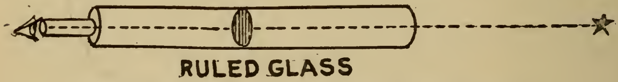


Fig. 167.—Ruled Glass in Transit Instrument.

ian—is set on an axis so that the telescope can be pointed to any place on the meridian but it cannot be moved east or west.

Sometime before a star is due to cross the meridian the astronomer sets his transit instrument so that the star will pass right across the line of sight of his telescope.

The purpose of observing the transit, or passing of a star is to see how much his wonderfully accurate clock has lost or gained during the past 24 hours. So his clock is right at hand.

The chronograph is another accurate clockwork which revolves a cylinder about the size and shape of a phonograph cylinder, and around which is wrapped a sheet of white paper. This cylinder makes one revolution every minute. A fountain pen marks a spiral line on the paper when the cylinder is revolving but at every second the pen is thrown out of position and this makes a notch in the line.

After starting the chronograph the astronomer takes an electric push button, which is connected with and controls the lever which holds the pen of the chronograph that makes the

notches, and takes up his position with his eye at the end of the transit instrument.

The instant he sees the star in the telescope he presses the button and this closes the electric circuit and makes a big notch in the line traced on the paper of the chronometer.

From the position of the big notch—which he caused to be made on the line when the star crossed the meridian and the little notches made regularly every second—he can dope out just how much his clock is in error—that is, how much it is too fast or too slow.

The next thing he does is to change this absolutely correct star time into mean solar time, when it is ready to be sent all over the United States east of the Rocky Mountains by telegraph. The Pacific Coast folks get their correct time from a Government observatory at Mare Island in San Francisco Bay.

How Time Is Sent by Telegraph.—The wires of the Western Union Telegraph Company run into the United States Naval Observatory at Washington, and for a few minutes each day all of this company's wires are controlled by the Government.

About five minutes before 12 o'clock noon, standard time at Washington, each day the wires all over the country east of the Rockies are *cleared* and all business and other messages are cut off for the time signals.

At five minutes of 12 sharp the United States Naval Observatory begins to send the beats of every second of the wonderfully accurate observatory clock, which are ticked out on telegraph sounders in all the cities and towns.

But no, not every beat, for the 29th second of each minute, the last 5 seconds of each of the first 4 minutes, and then the last 10 seconds of the last minute are not sent. The first click of the sounder after the 10 seconds' rest is the noon signal, and all local clocks are set by it.

In many cities the telegraph company has special wires running to various jewelry and other stores and these subscribers get the correct time direct by telegraph from the Naval Ob-

servatory for their sounders are connected in the regular line circuit.

The Time Ball.—The Bureau of Navigation got up what is known as the *time ball* for the benefit of sailing masters in particular and the townsfolk in general.

In New York and other cities along the seacoasts and lake ports a great ball, weighing in the neighborhood of 100 pounds,

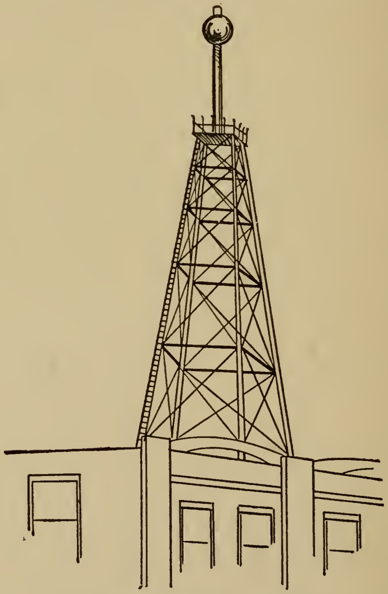


Fig. 168.—The Time Ball.

having a diameter of over 3 feet and with a hole in its center, is slipped over a pole or flagstaff some 20 feet in height, which is mounted atop of some high building where it can be seen to the best advantage.

The ball is held in position at the top of the pole by an

electro-mechanical trigger, which is placed directly in the electric telegraph circuit that runs into the Naval Observatory at Washington. When the time signals are being sent out from the observatory and the telegraph key is closed at exactly noon the trigger which holds the ball in place is released by the current and the ball drops. Fig. 168 shows a time-ball atop of the old Western Union Building in New York.

How Time is Sent by Wireless.—At Arlington, Va., just across the Potomac River from Washington, is one of the most powerful wireless stations in the world, having a sending range of at least 3,000 miles.

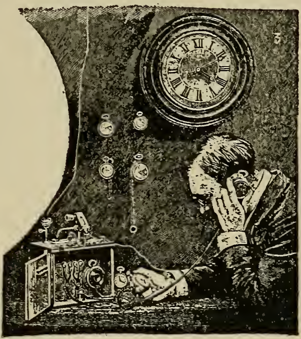


FIG. 169.—RECEIVING TIME SIGNALS BY WIRELESS.

Every day at noon time signals like those sent over the wires on land are sent out so that every navigation officer and sailing master whose ships are fitted with wireless apparatus can get the correct time.

All over the Atlantic seaboard boys, as well as jewelers (see Fig. 169), have wireless receiving sets and they receive the correct time every day by wireless free of charge. No license is required to receive wireless signals, the cost of the apparatus is little and the experience immense. Are you in on it?

CHAPTER XI

THE STARS OF THE ZODIAC

Zodiac!—It sounds to the untrained ear like the password of a bomb-thrower or a first cousin to a dish of Hungarian goulash.

It is enough, albeit, to scare even a Scout away from the stars, but be not afraid, for it can't hurt you and you can't eat it.

On the other hand, if you are on speaking terms with the zodiac (pronounced zo′-di-ak), it will help you to find the planets and at the same time you will add enough new constellations to those you already know to give you a high passing mark for a merit badge in the Boy Scouts if you want one. Besides, the signs and constellations of the zodiac will aid you to use the almanac and help you in many other ways.

You have often noticed that the Sun seems to travel through the sky over a path or belt that is always the same from east to west; you must have noticed, too, that the path of the Moon is almost the same as that of the Sun, but you may or may not remember that the planets also travel over the same path as the Sun and Moon.

It is just as though the Sun, Moon and planets were all fastened on a great endless belt in the sky which turns round the Earth nearly in a line with its equator, though tilted at a slight angle to it, and this line is called the *ecliptic.* The way the ancients thought it was and the way it really looks to us is shown in Fig. 170.

The ancients called this apparent path of the Sun, Moon and planets with the stars for a background the zodiac, so it is not such a horrible specimen after all.

We know, of course, that the Sun is the center of our solar system and that the planets, including the Earth and Moon, are at various distances from the Sun and that each moves in a

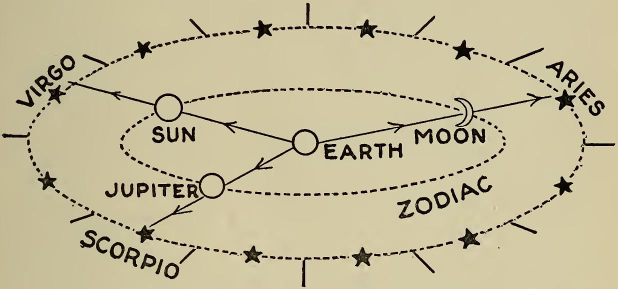


FIG. 170.—THE ZODIAC AS INVENTED BY THE ANCIENTS.

path, or orbit, of its own, so that what we call the zodiac is really a belt a little wider than the path of the Sun caused by the Earth traveling round it.

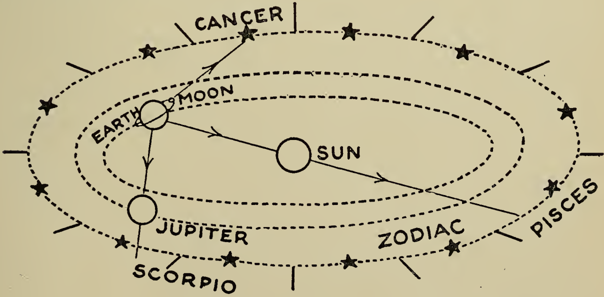


FIG. 171.—THE ZODIAC AS WE KNOW IT TODAY.

Suppose we draw a little circle and call it the Sun, as shown in Fig. 171, and draw an ellipse around it and call it the Earth's orbit, putting on another little circle for the Earth; now sup-

pose we draw a much larger ellipse round the one representing the Earth's orbit, divide it into 12 parts and put a constellation in each part.

Knowing now that the Sun, Moon and planets are very near the Earth when compared with the fixed stars it must be plain that these bodies when seen from the Earth, which is always changing its position in its travels round the Sun, would appear to move in and across the constellations.

Take a look at Jupiter some night when he is moving across any of the constellations and he will seem to be a part of it; this is the reason we speak of the Sun or a planet as being in a certain constellation at a given time.

The stars forming the background of the Moon and the planets can always be seen, for we are then looking at them from the dark side of the Earth, but they cannot be seen when they form the background of the Sun, for the stars are on the other side of him when he gets between us and them and he shines in our eyes.

These constellations through which the Sun, Moon and planets seem to pass, or as the almanacs say are *in,* lie in a belt formed by the path of the Sun and neither the Moon nor the planets ever get farther from the path of the Sun than 8 degrees on either side of him and this belt is called the zodiac.

The belt, or zodiac, is divided into 12 equal parts, or spaces, which were called *signs* by the ancients and they are still called signs. This makes the length of each sign, or space, 30 degrees, and hence the 12 signs, which are called the *Signs of the Zodiac,* equal 360 degrees or a complete circle. (See Chapter X, *The Time o' Day.*)

The Signs of the Zodiac have the following constellations in them in this order: *Aries,* the Ram; *Taurus,* the Bull; *Gemini,* the Twins; *Cancer,* the Crab; *Leo,* the Lion; *Virgo,* the Virgin; *Libra,* the Balance; *Scorpio,* the Scorpion; *Sagittarius,* the Archer; *Capricornus,* the Goat; *Aquarius,* the Water Bearer, and *Pisces,* the Fishes. It is in one of these constellations that the Sun, Moon and planets are always to be found.

A good way to find any one of the constellations is by knowing the time when it will be on your meridian, that is the line due north and south which you are on, during a given month. Any constellation of the zodiac will be on your meridian at 9 o'clock P. M., during the month given opposite its name in the following table:

Astronomical Names	How Pronounced	Common Names	Time Constellation will Appear on Your Meridian at 9 P.M.
Aries..........	A′-ri-es	The Ram	December
Taurus........	Tau′-rus	The Bull	January
Gemini.........	Gem′-i-ni	The Twins	February
Cancer........	Can′-cer	The Crab	March
Leo............	Le′-o	The Lion	April
Virgo	Vir′-go	The Virgin	May
Libra..........	Li′-bra	The Balance	June
Scorpio.......	Scor′-pi-o	The Scorpion	July
Sagittarius...	Sag′-it-ta′-ri-us	The Archer	August
Capricornus...	Cap′-ri-cor′-nus	The Goat	September
Aquarius......	A-qua′-ri-us...	The Water-Bearer	October
Pisces.........	Pis′-ces	The Fishes	November

To find any constellation during any other month than that given in the last column above subtract two hours for each following month. Suppose you want to find Aries, the Ram, in January instead of December, look for it on your meridian at 7 P. M.; in February look for it at 5 P. M., and so on.

You will of course come to a month where the constellation will run into daylight and then you won't be able to see it again until the Earth has traveled round the Sun to a point where the Earth is again between the Sun and the constellation.

The constellations of the zodiac are shown in Fig. 172; in this figure they are marked on a strip which is divided into 12 signs, or parts, and in these the chief stars of each of the constellations are placed.

If you look southward at the sky some night for any particular constellation you need not expect the stars which form it

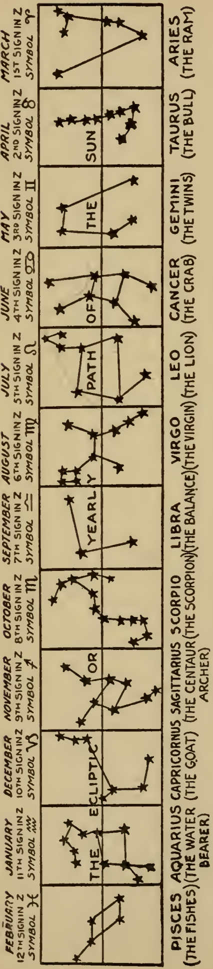


Fig. 172.—Constellations and Signs of the Zodiac.

to stand out separate and distinct, as shown in Figs. 172 and 174; if you do you will be sadly disappointed, for many of the constellations of the zodiac are very poor specimens compared with the Big Dipper, or Orion, or Pegasus.

Nor are the constellations of the zodiac measured off in the sky by any such even lines as are shown in Figs. 172 and 174. On the contrary some of the stars are very scattered and stretch over part of two signs of the zodiac, while others do not take up nearly all the space allowed them, but all 12 are there—count 'em.

The heavy black line drawn lengthwise through the middle of the strip in Fig. 172 represents the line of the ecliptic which is the yearly path the Sun seems to take. The planets also take the same course, though they may be on one side or the other of the Sun's path—the black line of the drawing—by 8 degrees, thus making the zodiac 16 degrees wide; hence, the lighter parallel lines on either side of the black line, or path of the Sun, is the farthest away that the planets ever get.

If you were to cut the strip of paper, Fig. 172, out of the book and paste the ends together, you would have a band, or circle repre-

senting the zodiac more nearly as it is; but instead of cutting the book you had better draw the signs and constellations on a strip of cardboard 2 inches wide and 24 inches long and glue the ends together, as shown in Fig. 173; you will now have a zodiac with which you can do a little experimenting.

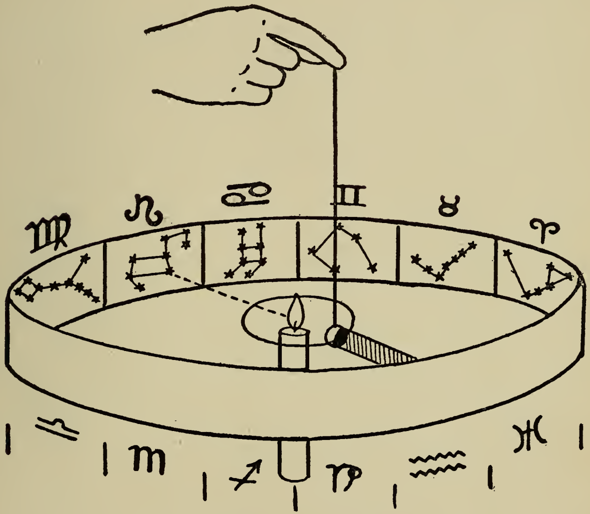


FIG. 173.—CARDBOARD ZODIAC.

Place a candlelight in the center of the cardboard ring and suspend a marble from a thread, by means of a drop of sealing wax, and let the marble hang between the light and the cardboard zodiac. Now on whatever space, or sign on the band the shadow of the marble falls, the candle light, which represents the Sun, is said to be in the constellation in a line with the shadow on the opposite side.

In the almanacs our year begins with January and as the Sun is then in Aquarius this constellation is represented by a

picture of Aquarius, the Water Bearer; but in marking out the constellations of the zodiac on a flat strip of paper we begin with Aries, which is March, on our calendar and read them from right to left.

The reason for this is because the Earth travels round the

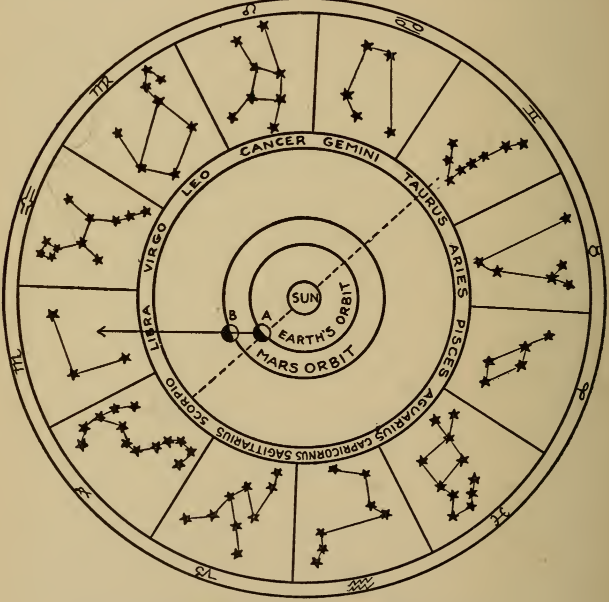


FIG. 174.—CONSTELLATIONS OF ZODIAC IN CIRCLE.

Sun from left to right when we face the north and this makes the Sun appear to move through the constellations of the zodiac from right to left.

This makes all the months follow each other in the proper order when the strip of paper is glued together, as shown in

Fig. 173, or when the constellations are arranged in a circle, as shown in Fig. 174.

This latter diagram shows plainly that when the Earth is at that part of its orbit marked A and we are on that side of the Earth which is toward the Sun the constellation of Taurus is back of the Sun, and of course we cannot see Taurus for the Sun, which is shining in our eyes.

Still Taurus is the background of the Sun just the same, and so when the almanac says the Sun is in Taurus you will know that the Sun is directly between the Earth and Taurus.

The same thing is true of all the planets. Take Mars, for example; whenever Mars is in that part of its orbit so that we can see it at night, as shown at B, Fig. 172, we also see the constellation back of it—in this case it is Libra, the Balance—and since a planet and a fixed star look exactly alike to the naked eye it is easy to think of Mars as being in that constellation; and it is the same with all the other planets.

The Constellations of the Zodiac.—The *Constellations of the Zodiac* and the *Signs of the Zodiac* are two very different things. Long ago, when the zodiac was invented, the constellation of Aries, the Ram, was in the first of the 12 spaces and he and the *sign* of this space were of course at that time the same.

Owing to a peculiar motion of the Earth, called *precession*, the constellations of the zodiac have moved forward during the last 2,000 years and the space, or sign, as it is called, where Aries used to be is now occupied by the Pisces, the Fishes, but the sign of this space is the same now as it was then.

Aquarius, the Water Man.—A constellation of autumn: Aquarius is always pictured in the almanacs as pouring water from a pitcher.

All the stars of this constellation are faint and scattered

and none of them are in a line with the ecliptic. Aquarius got his name from the Romans, who called him the *Waterman* because when the Sun enters the constellation in January there are usually heavy rains in Italy and in the long ago people thought the stars had a lot to do with the weather, and everything else on Earth, for that matter.

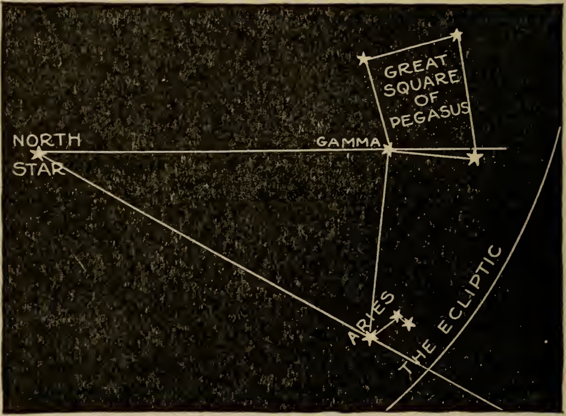


FIG. 175.—CONSTELLATIONS OF ARIES THE RAM.

Pisces, the Fishes.—This constellation is now in that part of the zodiac whose sign is ♈ (Aries). It is not an interesting constellation to look at with the naked eye, for its stars are faint and they stream out in two lines over nearly two signs of the zodiac.

But Pisces is none the less a very important constellation because it is at one of the points where the line of the equator crosses the line of the ecliptic.

When the Sun crosses the point where the equator and the ecliptic meet the days and nights are then equal at all places on the Earth, and hence we call this time of the year, which is about the twenty-first of March, the *equinox,* which means

equal days; or the *vernal equinox,* which means equal spring days.

Aries, the Ram.—This constellation used to be in that part

of the zodiac whose sign is ♈ (Aries) but is now in that part whose sign is ♉ (Taurus).

The position of Aries in the sky is shown in Fig. 175 and you can easily find him by drawing a line from the North Star

to *Gamma* in Pegasus and another line at right angles to the first line until you come to two bright stars quite close together and these are the chief stars of the constellation of the Ram.

Taurus, the Bull.—This constellation is now in the sign ♊ (Gemini), of the zodiac. In Chapter II you will find directions for locating Taurus. You will remember that the red

star Aldebaran forms the right eye of the Bull. The little group of stars called the *Hyades* is the Bull's face and the Pleiades are in his shoulder.

Gemini, the Twins.—It is easy to see why the ancients called this constellation of the zodiac the Twins, for its two chief stars, *Castor* and *Pollux,* are very close together and while of different colors they are of about the same brightness.

These two stars are the heads of the Twins and four other stars are their feet and these stand forever on the Milky Way. The Twins are easily found since they are next to Taurus, the Bull.

Gemini is an important constellation, as the Sun reaches its most northern point in it in summer; this is called the *summer solstice,* and takes place about June 21. When the Sun has reached this point it casts the shortest shadow at mid-day and it seems to stand still for a few days before it takes its downward course. The summer solstice is halfway between the two points of the equinox.

Cancer, the Crab.—This is a small constellation of dull stars that is chiefly interesting because it was once the point of the summer solstice, but that was ages ago.

The only thing about Cancer to attract attention is a hazy patch of light called the *Manger.* On each side of the Manger

is a fairly bright star and this pair of stars is called the *Ass's Colts;* they will help you to find Cancer.

The Manger has often been mistaken for a comet by those who lit upon it with the naked eye, but it is really a cluster of small stars.

Leo, the Lion.—There are two separate groups of stars that make up this king of beasts. The first group takes the shape of a *sickle* and the other the form of a *square.* The sickle, which is formed of six bright stars, is Leo's head and shoulders, and

the four stars of the square make up his hindquarters.

Two lines, drawn from the Big Dipper across the sky until they touch the path of the Sun, or ecliptic, as shown in Fig. 176, will meet the sickle and the square.

The very bright star in the end of the handle of the sickle is *Regulus,* which means little king, and far to the other side

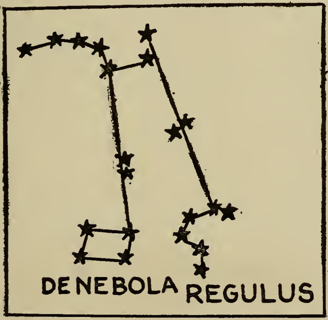


FIG. 176.—CONSTELLATIONS OF THE LION AND BIG DIPPER.

of the constellation right in the end of the Lion's tail is another bright star called *Denebola.*

Virgo, the Virgin.—This constellation is of interest, because the Sun again crosses the point where the equator and ecliptic meet, and the days and nights are again of the same length everywhere on the Earth, just as they were at the spring, or *vernal equinox.*

But this time, when the Sun is in Virgo, it crosses the line of his journey south about September 21 and so this *equinox*

is called the *autumnal equinox,* which means equal autumn days.

By drawing a line through the handle of the Big Dipper and producing it to Arcturus, and on until it reaches a big,

bright, white star you will have reached Virgo, as shown in Fig. 177. This big, white, bright star is Spica, and it is the chief star in Virgo.

The ancients always represented Virgo, the Virgin, with a sheaf of wheat in one hand and a sickle in the other. The Virgin and the harvest always went together in the minds of the ancients and this accounts for the pictures of Virgo in the almanacs of the present time.

Libra, the Balance.—A small constellation named for the ancient Roman pound weight.

The constellation of Libra is not nearly as old as the others in the zodiac, in fact it is thought that there were only eleven

constellations in the zodiac when they were first mapped out thousands of years ago, although there were twelve signs or spaces in the zodiac. Its position is shown in Fig. 178.

Then in the days of the Roman Empire, about 300 years before Christ, some genius clipped the claws of the Scorpion and made its stars into a pair of scales. This was a very clever idea, for the autumnal equinox then took place in this sign of the zodiac, and the stars in this sign were given the name of Libra, as the equal days and nights called to mind the balance.

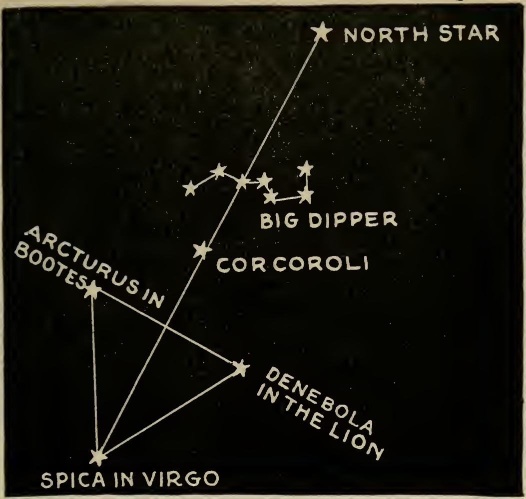


FIG. 177.—CONSTELLATIONS OF VIRGO THE VIRGIN.

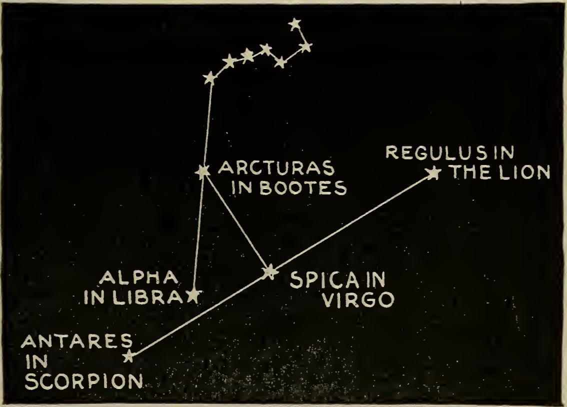


FIG. 178.—LIBRA, LION, SCORPIO, VIRGO.

Scorpius, the Scorpion.—A summer constellation. If Libra takes up only a small part of one sign of the zodiac Scorpius makes up for it by nearly covering two signs.

To the old astrologers, Scorpius was the "power of darkness" and the "accursed constellation," and when they cast their *horo-*

scopes they attributed to it "woe and discord, war and disease."

The constellation of Scorpius is one of the very few which really looks its part. In the end of its curved tail there are two stars which are ready to sting if he ever strikes, but he has never struck yet.

The heart of the Scorpion is a big, bright red star called *Antares,* which means the rival of Mars, and when Mars is in the constellation of Scorpius it is hard to tell them apart.

Antares will prove useful in finding the Scorpion as there are no other bright stars in that part of the sky. The position of Scorpius is shown in 178.

Sagittarius, the Archer.—A summer constellation: It is made up of eight stars which can be seen with the naked eye

and is always pictured in the almanacs as a *centaur,* or man-horse, shooting an arrow from a bow at the heart of the Scorpion.

Sagittarius is a fine constellation, right in the path of the Milky Way, and this makes it easy to find. There are several interesting things in this constellation and among them are the clusters of stars and nebulæ.

Then there are seven stars in Sagittarius, which make a little dipper turned upside down, and because it is in the Milky Way it is called the *milk dipper;* when you once find it, you will never

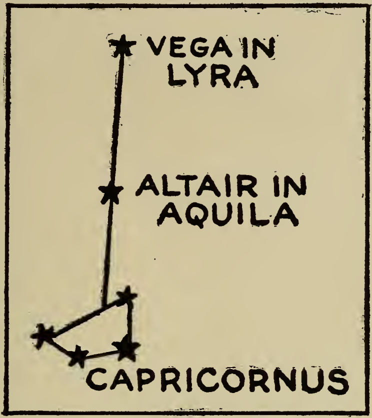


Fig. 179.—Lyra, Aquila, Capricornus.

be able to see Sagittarius again without seeing the milk dipper.

The *winter solstice,* that is, when the Sun reaches its most southern point, lies halfway between the constellations of Scorpius and Sagittarius and also between the two stream lines of the Milky Way.

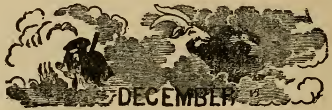
When the Sun reaches this point, which is the 20th of December, the noonday shadows are the longest and the Sun seems to again stand still until Christmas, when he will begin to move north once more.

Capricornus, the Sea-Goat.—A constellation of autumn: On the same plan that the ancients made Sagittarius a man-horse, so they made Capricornus a goat-fish.

Though Capricornus is a small and poor constellation when viewed with the naked eye, the early astrologers thought more

of him than all the other constellations of the zodiac put together.

While the stars of Capricornus do not look anything like a sea-goat, he can be easily found by drawing a line from Vega in



Lyra to Altair in Aquila and produce it until you come to the zodiac as shown in Fig. 179.

The two brightest stars of Capricornus are in his head. One of these stars is a naked eye double, but to many people it will seem merely a single star. As a matter of fact it is a fine sight test, for it takes a pair of mighty good eyes to separate them. Another bright star of the sea-goat is in his fishlike tail.

We have journeyed clear around the great circle which the Sun travels every year, and we are back again to Aquarius, the constellation we started from, having covered all the constellations of the zodiac.

The Signs of the Zodiac.—Where the signs of the zodiac are used in almanacs they do not mean the constellations of the same name at all, but the spaces or parts of the great circle which form the zodiac.

Two thousand years ago the constellations and the signs of the same name were in the same spaces or parts of the zodiac, but the constellations have shifted over one space to the east since that time, while the signs which used to represent them are still in the same spaces, and this has made a good deal of confusion.

It's a pretty skillet of fish, this mixing of the signs and constellations of the zodiac, but you will get used to it just as easily as you get used to carrying water when in camp or washing dishes.

How to Read the Almanac.—If you were asked to find the

date of any day of any month of the year you would simply look at a calendar and find it in a jiffy.

Now, long before calendars came into general use the almanac was freely consulted, not only for learning days and dates, but for much more useful information, such as finding the dates of eclipses, the beginning of seasons, the rising and setting of the Sun, Moon and planets and the *conjunctions* and *oppositions* of these bodies, planting potatoes and the year the father of your country was born.

To read an almanac easily you should learn the following signs:

⊙	The Sun	☿	Mercury
○	Full Moon	♀	Venus
☾	Last Quarter	⊕	The Earth
●	New Moon	♂	Mars
☽	First Quarter		
♃	Jupiter	☌	Conjunction
♄	Saturn	☍	Opposition
♅	Uranus		
♆	Neptune		

Conjunction—When this sign is used it means that two planets, or the Sun and a planet, or the Moon and a planet, are on the *same* side of the Earth.

Opposition.—When this sign is used it means that two planets, or the Moon and a planet, are on the side of the Earth *opposite* to the Sun.

To see how these signs work out suppose you look up the month of January, 1915, in an almanac.

The first line, besides showing that it is the first day of the year, the first day of the month and that it is Friday, also shows that the ○ (Moon) is full. It further gives the time the ⊙ (Sun) rises and sets, the length of the days in hours and minutes, the ○ (Moon's) age in days, and when it rises and sets.

Then on the same line the following signs are given: ☌ ☿ ♂ and this means that a conjunction of Mercury and Mars will take place on this date; that is, that they will be nearer to each other from our line of sight than at any other time for a long while.

On the next line, which is the 2nd of January, the following signs are given: ♀ *greatest brilliancy;* ⊕ *in perihelion* ☌ ♆ ☾; the first of which means that Venus has reached its greatest brightness; the second, that the Earth is the nearest to the Sun that it will get, and the third, that there is a conjunction of Neptune and the Moon; and so on for every day of the year.

Note: A good almanac for daily star information is the *Old Farmers' Almanac,* a copy of which you can get by sending 11 cents to William Ware and Company, Boston, Mass.

CHAPTER XII

VALUABLE INFORMATION

Photographing the Stars.—There are some interesting things you can do with an ordinary *camera* in the way of photographing the stars.

A camera is made up of three principal parts, and these are (1) a convex lens, which forms the image of the object to be photographed; (2) a light-tight box, which keeps out all the light except that which passes through the lens, and (3) a plate, or film holder, which holds the sensitive plate, or film, in the camera and keeps it perfectly dark until you are ready to have the image formed on it.

The instant the lens is allowed to form an image on the *sensitive plate,* or *film,* we get out of the *optics* of photography and into the *chemistry* of it.

The sensitive plate, or film, is coated with a thin layer of salts of silver and bromide, heated with gelatine and a little water, and when these substances are thoroughly mixed, an *emulsion* results, and this is spread on glass plates or on celluloid films. When the plate is exposed, that is, when the image has been formed on it, it is developed. The developing is done by placing the plate in a solution of *pyrogallic acid,* or *hydroquinone* and water.

The plate, or film, is now put in the *fixing bath,* which is simply a solution of *hyposulphite of soda* and water. This fixing bath prevents any further action of the light on the plate, or film.

But the picture on the glass plate, or celluloid film, looks all samee like a Chinese chromo, for the light and dark parts

are just the reverse of that of the object which was photographed; in other words, where the picture should be white, it is black, and where it should be black, it is white, and this is the reason it is called a *negative.*

To get a picture of the object, as it looks to the eye, a sheet of paper, also coated with salts of silver, is laid flat on the negative and held close to it in a *printing frame* when it is exposed to the light of the Sun.

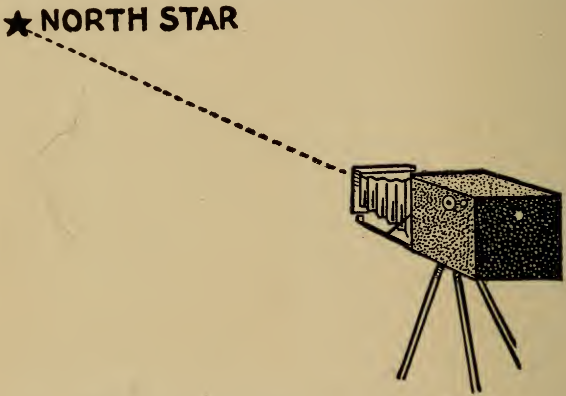


Fig. 180.—Camera Pointing to North Star.

When the paper is printed dark enough by the Sun, it is *toned* to give it a pleasing color and *fixed* to make it last a long time, and when washed and dried the image of the object, true to life, is there, a wonderful record for all time, nearly.

This then, briefly, is how the Sun, or other source of light, makes an image, how the image is fixed on a dry plate, or film, and how a picture is printed from the negative, and having found out this much let's see how we can make it do a little star work for us.

There is not much we can do in the way of making pictures of the things in the sky with a small camera, but the few things

we can do are mighty interesting, and show the stars in a way you can never see them with the naked eye.

To make *star trails* is one of these interesting things. First, set your camera on a *tripod,* or other firm support, and focus it on a tree or something as far off as you can see it in the daytime. Now, on a dark night, when there is no Moon, set your camera so that the lens is pointing directly at the North Star, as shown in Fig. 180. Set the shutter of your camera for a *time exposure* and open it.

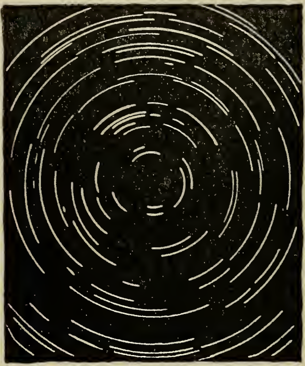


Fig. 181.—Star Trails.

You can go to bed now and let the stars work for you while you sleep, that is if you can get up before daylight the next morning, but if you cannot do this stay up as long as you can, three or four hours, anyway, before you close the shutter.

Now, when you develop the plate, or film, and make a print from it you will have a record of the apparent path of the stars, as shown in Fig. 181, but which is, of course, due to the Earth turning round on its axis. If you set your camera with the lens pointing toward the ecliptic, that is, the path of the Sun, the star trails will be long, straight lines, and this will make another interesting record.

By pointing your camera toward that part of the sky and during that time of the year when there are showers of meteors, and opening the shutter of your lens, you stand a chance, though it is not a very fat one, of catching one of these wily shooting stars on your plate, and if you do succeed—well, you will have a picture that is a curiosity.

You can photograph the Sun with an ordinary camera and make his disk as large as you want to, but you will get nothing

more on your plate than a white spot. The Moon can likewise be photographed, but if you focus it sharp on the plate it will not be much larger than a mere point of light, and if you get a disk large enough to see there will only be a small white spot on your finished print.

To make good photographs of the Sun, Moon and planets, a big telescope driven by clockwork to offset the turning of the Earth is needed. Such a telescope is called an *equatorial telescope,* and when it is set so that an object in the sky is in the field of view, it will remain right there as long as you want it, and when you make a photograph of the object it will be as sharp and as clear as though both it and the Earth were standing perfectly still.

If you think enough of the stars to try to photograph them with your little camera, I should say there is a very good chance of your being able to photograph them sometime through an equatorial telescope for *all things come to the boy who wants them hard enough.*

What the Stars Are Made of.—To know what the stars are made of is to know more about them than men knew of the Earth a few hundred years ago.

But just think of looking at a star like Aldebaran, which is so far away that it takes 45 years for its light to reach the Earth—light travels eleven million miles a minute—and then saying it is made of iron, and mercury and hydrogen and sodium and half a dozen other substances!

Now you ask, "How is it done?" And I'll say with a *glass prism,* and then we'll have made a flying start. Now a glass prism is a three-sided piece of glass—the ends don't count—as shown in Fig. 144, and it is just as wonderful in its way as a lens is wonderful in its way.

If you will hold a prism to your eye and look at the flame of a candle through it, you will see the flame in all the brilliant colors of the rainbow, and these bright colors form what is called a *spectrum.*

Now make another experiment; cover a window, on which

the Sun shines, with a sheet of cardboard, in the middle of which you have cut a horizontal slit with a sharp knife, about 1 inch long and $^1/_{25}$ inch wide. Make the room perfectly dark except for the light which comes in through the slit in the cardboard, and set a prism in front of the slit, as shown in Fig. 145. The beam of sunlight which passes through the prism will be split up, or *decomposed,* as it is called, into the seven colors of the rainbow, but the colors will be much brighter.

If you will fix another sheet of white cardboard in a *vertical* position so that the colors will shine on it in a band, the colors, beginning with red at the bottom, next orange, then yellow, green, blue, indigo and violet, will follow each other to the top bright and beautiful. These rainbow colors, spread out in a band on the screen, form what is called the *solar spectrum,* that is, the spectrum which is produced by sunlight.

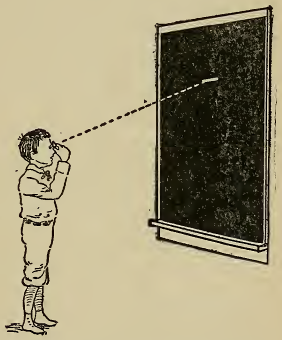


Fig. 182.—Boy Looking through Prism at Slit in Cardboard.

While the spectrum in the above experiment is most beautifully colored, it is not a pure spectrum, for the colors overlap each other. In a pure spectrum each color is separately spaced off by *dark lines,* and these dark lines are just as important in finding out what the Sun and other stars are made of as the colors in between them.

It is easy to produce a pure spectrum if you have a very narrow slit in the cardboard over the window, for all you have to do is to stand away from it five or six feet and look at the beam of light through a prism just as you did at the flame of the candle. This is the simplest form of a *spectroscope,* that is an instrument for splitting up the light of any object which is self-luminous, into a spectrum, as shown in Fig. 182.

When you look at the sunlight streaming in through the slit in the cardboard you will see a number of dark lines separating the different colors. These dark lines are called *Fraunhofer's lines,* because Fraunhofer, who was a German telescope maker, was the first to show how important they are. The chief dark lines of the pure spectrum are known by the letters of the alphabet, and, like the colors they separate, they are always in the same place. They are shown in Fig. 183.

Having found out a little about the spectrum and how it is formed by the Sun, let's find out next how it tells us what the Sun and the stars are made of.

Now, in the pure spectrum there are a pair of lines close together and near the middle which are called the D lines—

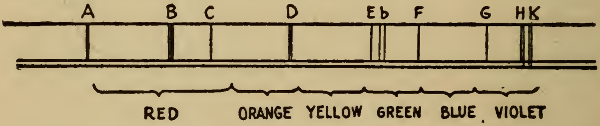


FIG. 183.—FRAUNHOFER'S LINES.

see Fig. 183—and when a beam of sunlight is split up by a spectroscope, or rather by the prism of a spectroscope, there is always a bright yellow light between these D lines.

There was a time, and not so very long ago, when no one had the faintest idea why the Sun produced this bright yellow light between the D lines when a candle flame nor any other kind of ordinary flame would make it. Then experimenters got busy burning every kind of substance they knew of and making the flame produce a spectrum, for some substances when burned make one color, or a number of colors, and other substances make another color, or combination of colors.

Then one fine day some one burned a little sodium, and lo and behold there appeared the same bright yellow light between the D lines of the spectrum that the Sun makes.

When this happened it did not take long for astronomers

to guess that the bright yellow light between the D lines of the solar spectrum was made by the light of sodium which is burning in the Sun.

In the same way iron and other metals and sodium and other substances which are heated until they become gases, and hydrogen and other gases which are aflame, produce certain colors between certain dark lines of the spectrum, and as the light from the Sun also produces the same identical colors between the same identical lines, it is known that the Sun contains these different substances which are burning up in it at white heat.

It's the same thing with the stars. It makes no difference if the light is made by burning some substance a few inches away from the slit of the spectroscope, or whether it has traveled

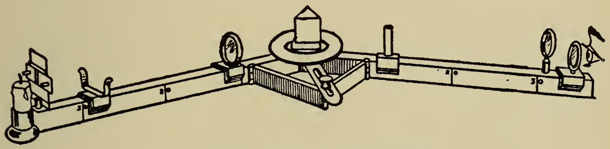


Fig. 184.—The Spectroscope.

90 millions of miles from the Sun—which takes about 8½ minutes, or 45 years for the light to reach it from Aldebaran, it always acts exactly in the same way; and so we know a good deal about the stuff the stars are made of.

Let's see now, how a real spectroscope is made, for it isn't always convenient to have a pitch dark room, nor is it a very exact way to hold the prism to your eye when examining the light of burning sodium, or hydrogen gas, or other substances.

The spectroscope is an instrument made so that the light of a substance burned at one end will pass through a prism and will form a spectrum on the retina of the eye at the other end. It is usually made up of two tubes mounted on a stand at an angle with the prism between them, as shown in Fig. 184.

In the end of the first tube, which is called a *collimator,* a very narrow slit is cut, and it is at this end that the substance

is placed which is to be burned and whose light is to be split up and examined.

A convex lens is fitted in the other end of the collimator, or first tube, so that the light after passing through the slit will then pass in a beam through the prism. The other tube—the one you look through—is called a *telescope* and in this one is fitted a convex object glass and an eyepiece which magnifies the spectrum made by the prism.

When a camera is used to photograph the spectrum the eyepiece is taken out of the tube of the spectroscope and a little camera is put in its place. In this way the camera and the spectroscope are combined and this helps chemists to compare the *spectra* of different burning substances far better than they could do with the naked eye alone.

To photograph the spectrum of the Sun the eyepiece of the big telescope is taken out and the end of the tube of the spectroscope with the slit in it is fitted in its place. In making a photograph of the spectrum of a star the slit is not needed, for the light of the star itself is but a mere point.

In photographing the spectrum of the Sun and stars three wonderful instruments are combined, namely, the *telescope,* the *spectroscope* and the *camera;* perhaps I should have said four wonderful instruments, for without the *brain* of a genius using them the Sun and stars never would have given up their secrets.

APPENDICES

APPENDIX A

According to the official *Handbook of the Boy Scouts,* if you are a Scout and want to win a merit badge for starcraft, you must

(1) *Have a general knowledge of the nature of the stars and planets.*

(a) By the nature of the stars and planets is meant their colors and what they are made of. Their sizes and their distances from the Earth in a general way may also be included.

(b) It is easy to tell the color of both the stars and the planets by looking at them, or by looking them up in the foregoing chapters.

(c) The spectroscope shows that the stars are made of metals and gases and other substances which we have on Earth. The planets are probably made of the same kinds of metals, gases and substances as those which form the Earth, but there is no way of proving this, for the planets shine by reflected light, and in this case the spectroscope is of little use.

(d) The stars are known to be suns as large or larger than our Sun; while the planets are about as large as our Earth—some smaller and some larger.

(e) All of the planets are within 2,800 millions of miles of the Earth, while the nearest star, except our Sun, is 25 trillions of miles from the Earth, or 8,000 times as far away.

(2) *Have a general knowledge of the movements of the stars and planets.*

(a) While all the stars revolve in orbits and are moving

through space at high speed, they are so far away from us that they seem to be fixed and for all practical purposes they may be considered to be fixed in their positions.

(b) All the planets turn on their own axes and travel in orbits round the Sun.

(3) *Point out and name* 12 *principal constellations.*

(a) Twelve easy constellations are: (1) The Big Dipper; (2) The Little Dipper; (3) Cassiopeia; (4) Pegasus; (5) Orion; (6) Auriga and (7) Taurus, all of which are shown in Chapters I and II; (8) Gemini; (9) Leo; (10) Virgo; (11) The Scorpion, and (12) Sagittarius, which are constellations of the zodiac, and are shown in Chapter XI.

(4) *Find the* **North** *by means of other stars than the Pole-Star (which is the North Star) in case that star is obscured by clouds.*

(a) This can be done by finding the constellation of Cassiopeia, see Chapter I; and also by Pegasus; Auriga and Orion, as explained in Chapter II.

(5) *Have a general knowledge of the positions and movements of the Earth, Sun, Moon, and the Planets; and of tides, eclipses, meteors and comets.*

(a) By reading the chapters on the Sun, Planets, Earth and Moon and

(b) Other things in the sky carefully, you will be able to pass the requirements named in No. 5.

(6) *Plot on at least two nights per month for six months the positions of all naked-eye planets visible between sundown and one hour thereafter. The plot of each planet shall contain at least three fixed stars with their names or designations; colors of planets and stars are to be recorded as observed.*

(a) How to plot the position of a planet is fully explained in the chapter on Planets, but you should also read the one on The Stars of the Zodiac.

APPENDIX B

Figures.—When explaining the positions and forms of things, it is often necessary to use certain terms and figures, that is to say, lines which are either real or imaginary, but which can be drawn on paper. See Fig. 185.

(1) A *straight line* is, of course, a line which runs uniformly in the same direction, and which is regular and without curves. A straight line is the shortest distance between two points. (2) When we say that lines are *parallel,* we mean that they lie so that every part of each is equally spaced from the other. (3) A line is *horizontal* when it is parallel with the level surface of the Earth under it. (4) A line is *perpendicular* to the surface of the Earth when it is *plumb,* that is, in a line with the center of the Earth. (5) A *vertical line* generally means a plumb line. (6) A *right angle* is formed when a vertical, or a perpendicular, line meets a horizontal line. (7) A *circle* is a curved line, all points of which are equally distant from its center. *Circular* means round like a circle. (8) By *diameter* is meant a straight line drawn from one side, or half of a circle, to the opposite side through its center. (9) The *radius* of a circle is a straight line drawn from the center of a circle, or a ball, to its surface. (10) A *ring* is a disk or object having a circular hole cut in its center. (11) An *arc of a circle* is a part of a circle. (12) A *quarter circle* is, of course, the one-fourth part of a circle. (13) A *tangent* is the point on a circle where a line meets it but does not cut it. (14) An *ellipse* is an oval figure, drawn on a plane surface. (15) The *equator* is a circle which divides the Earth or other ball into equal parts, and is 90 degrees from the north and south poles.

(16) The *ecliptic* is a circle round the Earth which is in the same plane with the equator of the Sun.

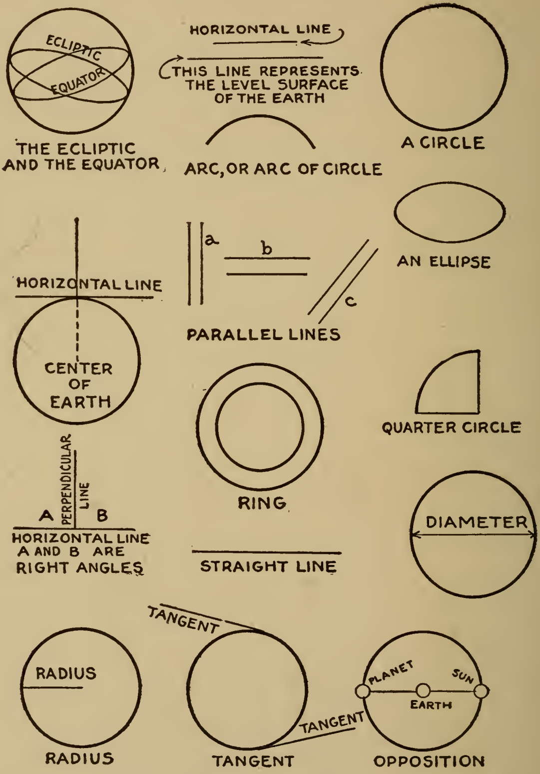


FIG. 185.—GEOMETRICAL FIGURES.

APPENDIX C

THE GREEK ALPHABET

Many of the brighter stars have names, as Aldebaran, Capella, Sirius, etc., but astronomers now indicate the stars of a constellation by the letters of the Greek alphabet. Thus the brightest star of a constellation is called α, that is, *Alpha,* the next brightest β, which is *Beta,* and so on until every star in the constellation has been given a letter.

The following is the Greek alphabet:

α Alpha	η Eta	ν Nu	τ Tau
β Beta	θ Theta	ξ Xi (Zi)	υ Upsilon
γ Gamma	ι Iota	o Omi'cron	ϕ Phi
δ Delta	κ Kappa	π Pi	χ Chi
ϵ Epsilon	λ Lambda	ρ Rho	ψ Psi
ζ Zeta	μ Mu	σ Sigma	ω Omega

APPENDIX D

STAR TESTS FOR EYESIGHT

There are a number of stars which are considered to be good tests for the seeing power of the eyes. The faint stars of the Pleiades are a fine test of this kind; but usually these tests are double stars and while one will be bright and easily seen its companion will be very faint. The test is to see the faint one, and if you can see it you may consider you have very good eyesight.

Eyesight tests are given on the following pages:

Page

11—Mizar and Alcor
34—Spots on the Sun
94—Grimaldi on the Moon

Page

119—Nebula in Orion
150—Epsilon in Lyra
150—Pleiades
182—Alpha and Beta in Capricornus

APPENDIX E

MAGNITUDE OF STARS

There are not nearly as many stars in the sky as you might at first suppose. The stars are divided into magnitudes, that is, according to their brightness. Stars of the first magnitude are the brightest stars; stars of the second magnitude are second brightest, and so on. The total number of stars which can be seen with the naked eye on any one night in the United States is probably not more than 3,000. The following table gives the number of stars of the different magnitudes up to and including the sixth:

Magnitudes	Number of Stars
1st	20
2nd	about 65
3rd	about 200
4th	about 500
5th	about 1,400
6th	about 5,000

APPENDIX F

FIRST MAGNITUDE STARS

The brightness of a star is known by its magnitude. A star of the first magnitude is one of the 20 brightest stars, and is $2\frac{1}{2}$ times as bright as a star of the second magnitude; a star of the second magnitude is $2\frac{1}{2}$ times as bright as a star of the third magnitude; and so on. A star of the sixth magnitude can just be seen with the naked eye on a clear night when there is no Moon.

Fourteen of the twenty first magnitude stars can be seen in the northern sky, and these are:

NAME OF STAR		NAME OF CONSTELLATION
1. Sirius, the Dog Star,	in	Canis Major
2. Capella	"	Auriga
3. Arcturus	"	Bootis
4. Vega	"	Lyra
5. Rigel (β)	"	Orion
6. Procyon	"	Canis Minor
7. Betelgeux (α)	"	Orion
8. Altair	"	Aquila
9. Aldebaran	"	Taurus
10. Spica	"	Virgo
11. Antares	"	Scorpius
12. Pollux	"	Gemini
13. Regulus	"	Leo
14. Deneb	"	Cygnus

APPENDIX G

CONSTELLATIONS HAVING FIRST MAGNITUDE STARS

The following important constellations are not described in the foregoing chapters of this book. They can be found, though, without trouble, since a star of the first magnitude is located in each.

Canis Major, the Big Dog, is a winter constellation, and can be seen on your meridian at 9 o'clock P. M. in February. Look for it in the southern sky and you will quickly find it because of the dazzling brightness of *Sirius,* the Dog Star.

Bootes (pronounced Bo-ō′-tes), the Bear Leader, is a summer constellation, and can be seen on the meridian at 9 o'clock P. M. in June. It is just this side of the ecliptic, or path of the Sun. It lies between a crown of stars and Virgo. You can't miss it, for midway is *Arcturus,* a red star of the first magnitude.

Lyra, the Lyre.—Is a summer constellation, and can be seen on the meridian at 9 o'clock P. M. in August. Look for it almost overhead, and you can't mistake it, for three bright stars, of which *Vega* is one, form a triangle.

Canis Minor.—The Little Dog: is a spring constellation, and can be seen on the meridian at 9 o'clock P. M. in March. It lies to the south of the constellation of Gemini, the Twins, and Cancer, the Crab. In it you will see *Procyon,* the Little Dog Star.

Aquila, the Eagle.—Is a summer constellation, and can be seen on the meridian in August. Look for it south of Lyra, and far to the west of Pegasus. The star that put Aquila on the map is *Altair.*

Cygnus, the Swan.—Is also a summer constellation, and

can be seen on your meridian at 9 o'clock P. M. in September. You will find it north of Pegasus and east of Lyra, and in it you will see the *Northern Cross* clearly traced out with seven stars, the brightest one being *Deneb,* a first magnitude star.

APPENDIX H

COLORED STARS

The following are a few stars which are highly colored—all the stars in the following list are first magnitude stars except the North Star:

WHITE STARS: Sirius, Regulus, Vega, and Polaris, the North Star.

BLUE STARS: Capella, Rigel, Procyon and Spica.

RED STARS: Aldebaran, Antares, and Betelgeux.

GREEN STARS: Altair and Deneb.

YELLOW STARS: The Sun and Arcturus.

APPENDIX I

DOUBLE STARS

When two stars are very close together they form what is called a *double star,* but a real double star is one that cannot be resolved, that is separated, into two stars without the aid of a telescope.

The North Star; Rigel, Castor; Procyon and Sirius, are all famous double stars.

APPENDIX J

VARIABLE STARS

A variable star is one whose brightness changes from time to time. There are about 400 variable stars known, though very few of them can be seen with the naked eye. There are different reasons given for a star varying in brightness. Our Sun is a variable star, and we are told that this is due to his spots. Sirius, the Dog Star, is a double star, but instead of having a bright companion it has a dark one (see Appendix K, invisible stars), and this dark star gets in between us and the bright star every once in a while, or partly in the way, and so cuts off part of the light from Sirius. Again a double star formed of two bright stars which revolve round each other, as many double stars do, may eclipse one another, and this would cause a change in brightness. Here, then, are three good reasons for a star being variable.

The following *variables* can be seen with the naked eye:

Betelgeux, in Orion.

Alpha Cassiopeia, that is, the brightest star in Cassiopeia.

Beta Lyra, that is, the second brightest star in Lyra, and

Beta Pegasus, that is, the second brightest star in Pegasus.

APPENDIX K

INVISIBLE OR DARK STARS

Stars are born, live and die, just like human beings. All the stars, including the Sun, are either in the process of making, are at their brightest brilliancy, are dying out, or are cold and dead.

Procyon is attended by a dark companion, which has never been seen, but whose presence is known by its attraction on Procyon.

Sirius is attended by a dark companion, whose presence was known by its pull on Sirius 16 years before it was seen through a telescope.

APPENDIX L

THE EQUATION OF TIME

As we have seen in Chapter X every day of the year is exactly 24 hours long by our clock time. The time by the Sun is usually either ahead or behind clock time. The difference between

TABLE OF THE EQUATION OF TIME

Day of Month	January		February		March		April		May		June	
	m	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*
1..........	S 3	31	S 13	44	S 12	37	S 4	6	F 2	56	F 2	30
6..........	S 5	49	S 14	15	S 11	33	S 2	37	F 3	27	F 1	41
11..........	S 7	59	S 14	27	S 10	19	S 1	14	F 3	45	F 0	44
16..........	S 9	49	S 14	19	S 8	57	F 0	4	F 3	48	S 0	18
21..........	S 11	24	S 13	52	S 7	28	F 1	12	F 3	38	S 1	23
26..........	S 12	39	S 13	10	S 5	56	F 2	10	F 3	15	S 2	27
31..........	S 13	35	S 12	13	S 4	24	F 2	56	F 2	39	S 3	38

Day of Month	July		August		September		October		November		December	
	m	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*	*m*	*s*
1..........	S 3	28	S 6	10	S 0	6	F 10	8	F 16	18	F 11	3
6..........	S 4	24	S 5	46	F 1	31	F 11	41	F 16	17	F 9	3
11..........	S 5	11	S 5	8	F 3	13	F 13	4	F 15	56	F 6	51
16..........	S 5	46	S 4	15	F 4	58	F 14	16	F 15	13	F 4	30
21..........	S 6	9	S 3	9	F 6	45	F 15	13	F 14	10	F 2	2
26..........	S 6	11	S 1	51	F 8	29	F 15	54	F 12	45	S 0	28
31..........	S 6	12	S 0	24	F 10	8	F 16	16	F 11	3	S 2	55

clock time and Sun time is called the *equation of time,* and a table to show how many minutes and seconds the Sun is fast or slow, according to clock time, is given in the preceding table,

taken from "The New Astronomy," by Professor Todd, who has kindly permitted me to use it here. In the table **S** means that the Sun is slow, that is, that the Sun does not cross the meridian until after the clock shows noon, and **F** means that the Sun is fast, that is, that the Sun has crossed the meridian before the clock shows noon. **M** means minutes, and **S** means seconds above the figures.

APPENDIX M

THE KULLMER STAR FINDER

The star finder shown in the picture was invented by Dr. C. J. Kullmer, of Syracuse, N. Y., and has been highly praised by many great astronomers.

You should own one if possible, for you do not need to know anything about the stars to operate it. It is mounted on the principle of a big telescope, but it is a naked-eye instrument, an arrow taking the place of the telescope.

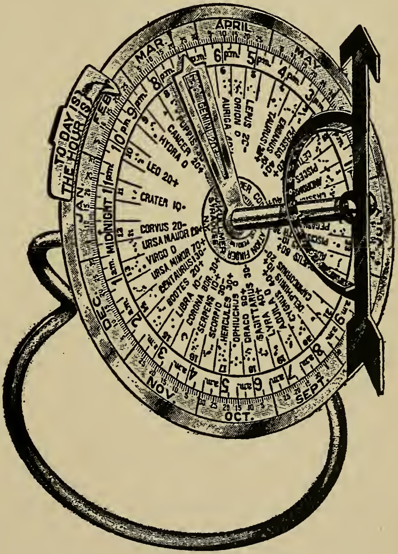


FIG. 186.—KULLMER STAR FINDER.

The finder is placed on a table, or other level surface, with the dial facing north. Then the pointer and dial are set for the day and hour when you want to find the position in the sky of a certain constellation. The indicator is turned to the name of the constellation on the dial, and this also tells the direction to set the arrow.

This is all there is to it and the arrow points right at the group of stars you want, whether they are above the horizon or not.

The finder can be used for many purposes, and it is a wonderful aid in making out in the sky the path of the stars, Sun, Moon and planets, and when they rise and set. In fact, it is a complete observatory on a small scale. Its cost is only $5.00.

APPENDIX N

THE ELLIS SEASONAL TWILIGHT CHART

A useful chart, designed by Miss E. Rebecca Ellis, of Wellesley College, Wellesley, Mass. It makes clear the changes in the lengths of the day, the phenomena of the seasons, etc. Its price is $1.00.

DEFINITIONS OF SOME WORDS AND TERMS USED IN THIS BOOK

Action. The way in which a thing works.

Affect. To act upon; to change; to be moved or influenced by.

Almanac. A pamphlet or book containing tables showing the days of the year; also the time the Sun and Moon rise and set; the conjunctions, eclipses and other information concerning the things in the sky. The word almanac is supposed to be derived from the Arabic article *al* and the verb *manac,* which means to count.

Angular measurements. See Appendix B.

Aphelion. The point where a planet or a comet is farthest away from the sun.

Apparent. To seem real. The motion of the Sun round the Earth is only apparent, for as we know it is the Earth which turns round on its axis instead.

Arc. See Appendix B.

Arc of circle. See Appendix B.

Aspect. (1) Any curious appearance of an object, especially if the object changes in appearance. (2) The figure formed by a planet with the stars of the constellation which it is in.

Astrologer. One who forecasts the life of a person on the supposition that the stars control it.

Astronomer. One who is skilled in seeing the stars and who knows them.

Atom. A very small particle of matter. See Molecule; Matter.

Attract. To pull toward. The attraction of the Sun and the Earth for each other is due to gravitation.

Attraction. A force which pulls one body to another.

Attraction of Gravitation. A force called gravity which pulls all bodies to each other.

Auditory nerve. A nerve that carries the impressions of sound which reach the ear to the brain.

Aurora borealis. The Northern Lights. A glowing light effect which takes place in the Arctic Circle. It can often be seen from our Northern States and sometimes from the Southern States. The

same kind of lights appear in the Antarctic Circle. These Southern Lights are called Aurora Australis.

Axes. Plural of axis.

Axis. An imaginary line on which a body turns.

Axis of rotation. An imaginary line round which anything turns or spins.

Axle. A wood or metal rod on which one or more wheels turn, or it may turn with the wheel or wheels.

Badge of merit. A badge awarded by the organization of Boy Scouts to members who can show a certain amount of skill in doing certain things. See Appendix A.

Band. (1) A flat strip of any material, or (2) such a strip whose ends are joined together.

Beam. Rays of light which are parallel. See Ray.

Bearing. (1) A piece of metal, or a bit of agate or other jewel, on which a pivot, spindle or shaft turns. (2) One's position as found by the Sun or stars, or by the compass, sextant or other means.

Body. Any separate and distinct amount of matter when held together. The Sun and Moon are heavenly bodies.

Degree. (1) The 360th part of a circle. (2) Indicated by this sign °.

Device. (1) An apparatus or instrument or any part thereof. (2) Any arrangement for producing a given result.

Diagram. A sort of shorthand picture of an apparatus or part of an apparatus. It is used to show in the simplest and clearest manner the construction of an apparatus.

Diameter. See Appendix B.

Direct line. A straight line.

Disk. (1) A circular plane or flat surface. Since the Sun, Moon and planets seem to be flat their surfaces are called disks. (2) Flat and circular like a coin.

Dog days. So called from the fact that Sirius, the Dog Star, rises at the same time as the Sun.

Ecliptic. See Appendix B.

Elastic. (1) A body that will stretch and return to its original size. (2) A thin piece of rubber.

Ellipse. See Appendix B.

Equator. See Appendix B.

Equatorial. Having to do with or affected by the equator.

Equatorial telescope. A telescope so mounted that its principal axis is parallel with the equator and so arranged that it will follow a star by affecting the motion of the earth.

Evening Star. A planet which can be seen in the west just after the sun sets.

Fixed. (1) Fastened to securely. (2) The stars are called fixed because they

never seem to change their positions.

Forecast. A prediction of some future event. A forecast may be founded on fancy or on fact. A horoscope of a person is a forecast based on the fancy of an astrologer. A weather forecast is founded on the action of a barometer, and even then the forecast is uncertain enough. Forecasts of the time of eclipses, the return of comets and the like are founded on cold scientific facts and hence come true at exactly the calculated time.

Frequency. A number of events which occur at regular intervals in a given time.

Gas. That form of matter which is like air. Gases remain in the gaseous state at ordinary temperatures. Gases have a tendency to expand without limit. See Vapor.

Generate. To produce. To set up; as a battery generates a current; the Sun generates power.

Gravitation. The force which attracts all bodies near the Earth to it and all bodies to each other.

Heavens. The sky. The space as far as the eye can see about the Earth. The space in which the stars and their planetary systems move.

Horizontal. See Fig. 185.

Horoscope. A forecast of the future of a person made by an astrologer who pretends to read the future from the aspect or position of the planets and stars.

Hyperbola. See Fig. 129.

Hypothesis. See Idea.

Idea. A notion of a plan or scheme which may be more or less vague. **Supposition.** A clearer conception of a plan or scheme which is based on such facts as may be thought of. **Hypothesis.** A plan or scheme assumed to be true and carefully reasoned out from all the facts obtainable. **Theory.** A plan or scheme which has been proved true by experiment, examination or comparison.

Illusion. An image which deceives the eye. The other senses can also be deceived by illusions.

Impact. Coming together of two objects.

Impress. To form on, or to affect, as light waves impress a dry plate.

Indicate. To show. To point out.

Indicator. That which points out or shows something.

Limb. The edge of the Sun, Moon or Planets.

Lore. Learning on any subject.

Lunar. Of, or having to do with the Moon.

Magnetic lines of force. The force of magnetism acting in and around a magnet.

Magnetic storm. The Earth is a great magnet and sometimes when sun spots of un-

usual size or numbers appear, the magnetic lines of force of the Earth are violently affected. This is called a magnetic storm.

Mass. (1) The size of a thing. (2) A lot of molecules or particles of matter brought and held together.

Matter. The substance of which a thing is formed. A molecule of matter is made up of atoms, and a mass is a lot of molecules held together by some attractive force.

Mercury. (1) The name of the planet nearest the Sun. (2) A silver white liquid metal.

Molecule. The smallest part of matter that can exist separately without the substance it forms being destroyed.

Morning Star. A planet which can be seen in the east just before the Sun rises.

Morse code. A telegraph code of dots and dashes invented by Samuel F. B. Morse. The Morse Code is used for telegraph and heliograph signaling.

Motion. Anything that changes position. There are two kinds of motion (a) simple motion and (b) compound motion. *Simple motion* can be either *translated* or *rotary,* while *compound motion* is both *translated* and *rotary,* so that while a body is being translated, or moved through space, it is also rotating on its axis. The Sun and planets, then, have compound motions.

Nature. Everything contained in space that has not been shaped by human hands.

Nautical almanac. The American Nautical Almanac is a book of the stars published by the Bureau of Navigation of the United States. It is published three years in advance and is sold by the Superintendent of Documents, Washington, D. C., at 30 cents per copy. This is designed chiefly for the use of navigators of ships. It gives the exact positions of the Sun, Moon and planets and much other astronomical information. It is based upon the calculations made by the United States Naval Observatory; these are printed in the Nautical Almanac, and on this all other almanacs are based.

Northern lights. See Aurora Borealis.

Obscured. Hidden from sight.

Official Handbook of the Boy Scouts. A book published by the organization of Boy Scouts and which contains the rules and regulations of that organization and the requirements they must meet in order to win merit badges.

Offset. To equal; to balance.

Opposition. See Appendix.

Optic Nerve. The nerve that carries the impression of light received by the eye to the brain.

Orbit. The path followed by a body. Atoms have orbits as well as the stars. The paths followed by planets and comets round the Sun.

Parabola. See Fig. 129.

Parallel. See Appendix B.

Particle. A bit of matter. A particle may be a bit of matter which can be seen or it may mean an amount so small that it cannot be seen.

Pencil. A group of rays from the same source of light. See Beam. See Ray.

Pendulum. A body suspended from a fixed point and free to swing in any direction.

Perihelion. The point where a planet or a comet is nearest the Sun. As the orbit of a planet is an ellipse and the Sun is in one of the foci; that is near one end, a planet comes nearest to the Sun when at this end of the ellipse; and when the planet is at the other end of its orbit, it is farthest away. See Aphelion.

Period. A certain interval of time which is marked by a repeated occurrence. The period of the Earth round its axis is about 24 hours. Its period around the Sun is 365 days.

Periodic. The time that elapses between two recurring events; as a periodic comet.

Perpendicular. See Appendix B.

Phase. One of the peculiar aspects of a heavenly body; as the phases of the Moon, or the phases of Venus.

Pivot. A pin, spindle or shaft on which a wheel, lever or device rotates or is rotated.

Plane. A level surface, as a table top.

Point. A sharp end. A starting place.

Pores. Minute spaces which separate the molecules of a substance.

Position. The place of a thing when compared to the places of other things.

Precede. To go ahead of. That which is before.

Precession. The act of going ahead or preceding. When a revolving body such as a spinning top or the Earth is acted upon by forces which tend to change the direction of its axis. This change in the direction of its axis is called *precessional motion*. The pole of the equator of the Earth makes a complete turn round the pole of the ecliptic in a little over 25,000 years and this change in the direction of the axis of the Earth causes the points of the *equinox*, that is the places where the *ecliptic* and the *equator* cross each other to move slowly from west to east and this is termed the precession of the equinoxes.

Prediction. To foretell; to forecast. Predictions may be based on fancy or founded on fact.

Principal. The chief one; the most important.

Principle. The cause of a result. That on which a thing is based.

Process. (1) The way of working. (2) The course of procedure.

Produce. In astronomy the word *produce* means the lengthening of a line. It is a mathematical term.

Protractor. See Fig. 98.

Quarter circle. See Appendix B.

Ray. (1) A single line of light or heat. (2) The path of light and heat.

Relative position. The position of a thing when compared with the position of something else. See Position.

Revolution. The turning of a thing completely round on its axis.

Revolve. (1) To turn completly round a circle. (2) To turn on an axis, as a top, or the Earth.

Rigid. Firm, that which cannot be easily moved out of its place.

Ring. See Appendix B.

Rise. To come into sight above the horizon, as the Moon rises.

Rotate. To turn completely round on an axis like a top or the Earth.

Rotary. Turning completely round on an axis, like a top or the Earth.

Roughly. Not exactly; nearly enough for practical purposes.

Schedule. (1) A tabulated statement giving items concerning a subject. (2) A timetable of any kind.

Seeing. To look at. The word *seeing* in starcraft means to observe the stars. *Good seeing* is to observe the stars when the atmosphere is perfectly clear.

Seems. Something which apparently is true and yet is not true.

Sensation. The action of one of the senses when excited by some change in matter. Light falling on the retina of the eye produces the sensation of light and color in the brain.

Set. To sink from sight below the horizon; as the Sun sets.

Sight. The power to see. See Sighting.

Sighting. To get the eye and two other objects, such as a telescope and a star, in a line, as to sight Jupiter with a telescope.

Sign. A mark, figure or letter which astronomers have agreed to use to represent certain stars, aspects of stars, parts of the zodiac, etc.

Solar. That which is of, or has to do with the Sun.

Spring stars. The stars which can be seen best during the spring months.

Star chart. A map of the positions of the stars.

Starcraft. Useful knowledge of the stars. Skill shown in making the stars serve useful purposes.

Star finder. A device of any kind which will enable an unskilled person to find the planets or constellations.

Star-lore. Learning concerning the mythology of the stars.

Summer stars. The stars which can best be seen during the summer months.

Supposition. See Idea.

Tangent. See Appendix B.

Tangent line. See Appendix B.

Telegraph code. The alphabet of dots and dashes.

Test. To try out. To examine, compare or make an experiment which will give a needed proof.

Theory. See Idea.

Thumb tack. A short, thin, sharp-pointed tack with a large flat head which permits it to be easily pushed into a board with the thumb. It is used by draftsmen for fastening paper to drawing boards.

Tilting. Leaning from a vertical or plumb line. The axis of the Earth is tilted from the perpendicular $23\frac{1}{2}$ degrees; this throws its equator out of plane with that of the sun, and the circle around the Earth that is in plane with the Sun is called the ecliptic.

Transparent. Said of any substance through which light can pass easily. Anything that may be seen through.

Twinkle. To blink. To flash with varying brightness. The twinkling of stars is caused by the atmosphere.

Uniform. Being the same all through or all along.

Vapor. A gas produced from a liquid or a solid and which returns to its original form at ordinary temperatures. See Gas.

Vertical. See Appendix B.

Vibration. A to-and-fro movement, as the vibration of a particle of matter. A constant to-and-fro movement over the same line.

Visible. That which the eye can see.

Wane. To gradually grow smaller. Said of the Moon.

Wax. To gradually grow larger. Said of the Moon.

Winter Stars. The stars which can best be seen during the winter months.

Wireless Messages. Messages which are sent and received by wireless telegraph stations.

Wireless system. An apparatus for sending and receiving messages by wireless telegraph.

Your meridian. The line running due north and south in the sky directly over your head. A meridian of this kind is called a celestial meridian.

Zodiacal lights. A faint glowing light which may be seen above the western horizon just after twilight during the clear evenings of winter and spring. It can also be seen just before daybreak during the clear mornings of summer and autumn.

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